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WATER RESOURCES STUDY

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WATER RESOURCES STUDY

LIST OF REPORTS AND APPENDICES

REPORTS

Summary Report

TECHNICAL REPORT

APPENDIX	TITLE
A	Surface Water
B	Geology and Groundwater
C	Water Use
D	Wastewater Generation and Treatment
E	Environment and Recreation
F	Demographic and Economic Characteristics
G	Plan Criteria
H (Volume 1)	Plan Formulation and Evaluation
H (Volume 2)	Plan Formulation and Evaluation
I	Institutional Analysis
J	Water Quality Simulation Model

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METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY.

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STUDY MANAGEMENT BY

Department of the Army, Seattle District
Corps of Engineers

CONSULTING ENGINEERS

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ACKNOWLEDGEMENTS

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The summary report was prepared by the Seattle District Corps of Engineers. The technical report and appendices were prepared for the Seattle District, Corps of Engineers by Kennedy-Tudor Consulting Engineers.

The Corps of Engineers expresses appreciation to the following individuals and groups for their assistance in conducting the study:

SPOKANE REGIONAL PLANNING CONFERENCE

Allen F. Stratton, Chairman	Spokane City Council
Cy L. Geraghty	Spokane City Council
Ray W. Christensen	Spokane County Commissioner
Jerry Kopet	Spokane County Commissioner
Milton Rawlings	Spokane County Planning Commission
May Lou Sullivan	Spokane City Plan Commission
Dr. William Wynd	Cheney City Council Representing Small Cities
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SPOKANE RIVER BASIN COORDINATING COMMITTEE

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E. Terry Clegg, Director	City Plan Commission
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W. A. VanLeuven	Lincoln County
Richard Nourse	Stevens County
Ralph S. Henning	Commissioner, Whitman County
Edward M. Pickett	Spokane County Health District
Alfred McCoy	Spokane Tribe of Indians
Ex Officio Member	
Rhys Sterling	Washington State Department of Ecology, Eastern Regional Office

PREFACE

With the enactment of the Federal Water Pollution Control Act Amendment of 1972 (Public Law 92-500), new national goals have been established for the elimination of pollution discharges into our streams and lakes. This report was prepared to assist local government in satisfying State and Federal requirements relating to Public Law 92-500. The study suggests a regional wastewater management plan for the metropolitan Spokane urban area and provides major input to Washington State Department of Ecology Section 303e plans for the Spokane River Basin in Washington State. Also included in the study are planning suggestions for urban runoff, flood control and protection of the area's water supply resources.

As listed on the inside front cover, documentation for this study consists of a Summary Report prepared by the U.S. Army Corps of Engineers, Seattle District, and a Technical Report with supporting Appendices A through J, prepared for the Corps by Kennedy-Tudor Consulting Engineers.

The consultant's technical report summarizes Appendices A through J which contain 58 individual task section reports prepared during the study.

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SECTION 1

INTRODUCTION

1. Introduction

This report presents the findings and suggestions of a Water Resources Study of the Metropolitan Spokane Region. The sponsoring agency, the Spokane Regional Planning Conference, is composed of representatives from the City of Spokane, Spokane County and other towns in the study area. The sponsoring agency has provided policy direction for the study through its subcommittee, the Wastewater Policy Committee. Technical coordination has been provided through the Spokane River Basin Coordinating Committee (SPRIBCO) which includes, in addition to representatives of the City of Spokane and Spokane County, representatives from the four adjoining counties in the study area (one each from Whitman, Lincoln, Stevens and Pend Oreille), the Spokane Tribe of Indians, the Spokane County Health District and the Washington State Department of Ecology. A focus for public participation was provided by the Citizen's Committee for the Metropolitan Spokane Region Water Resources Study (CITCOM). Study organization is shown schematically in Figure 1-1.

Study Scope, Goals and Objectives

The study area is the 2295 square miles drained by the Spokane River and its tributaries within the State of Washington. The 4345 square miles in Idaho which are drained to the Spokane River through its primary tributaries, the Coeur d'Alene and St. Joe Rivers, are not a part of the study area but must obviously be recognized as the source and determining factor in the hydrology and quality of the Spokane River as it enters the study area. Refer to Figure 1-2 for a map of the study area and its relation to the total Spokane River Basin. The control portion of the study area is shown in more detail in Figure 1-3.

The study area includes most of Spokane County (hereafter called County) and portions of adjoining Pend Oreille, Stevens, Lincoln and Whitman Counties. The primary focus of the study is, however, the urbanizing area centered on the City of Spokane (hereafter called City) which contains more than 85 percent of the present and projected population of the study area.

The goal of the study is the preparation of a planning report on water resource management for the study area. The planning report is to be the culmination of an extensive program of data gathering, projection

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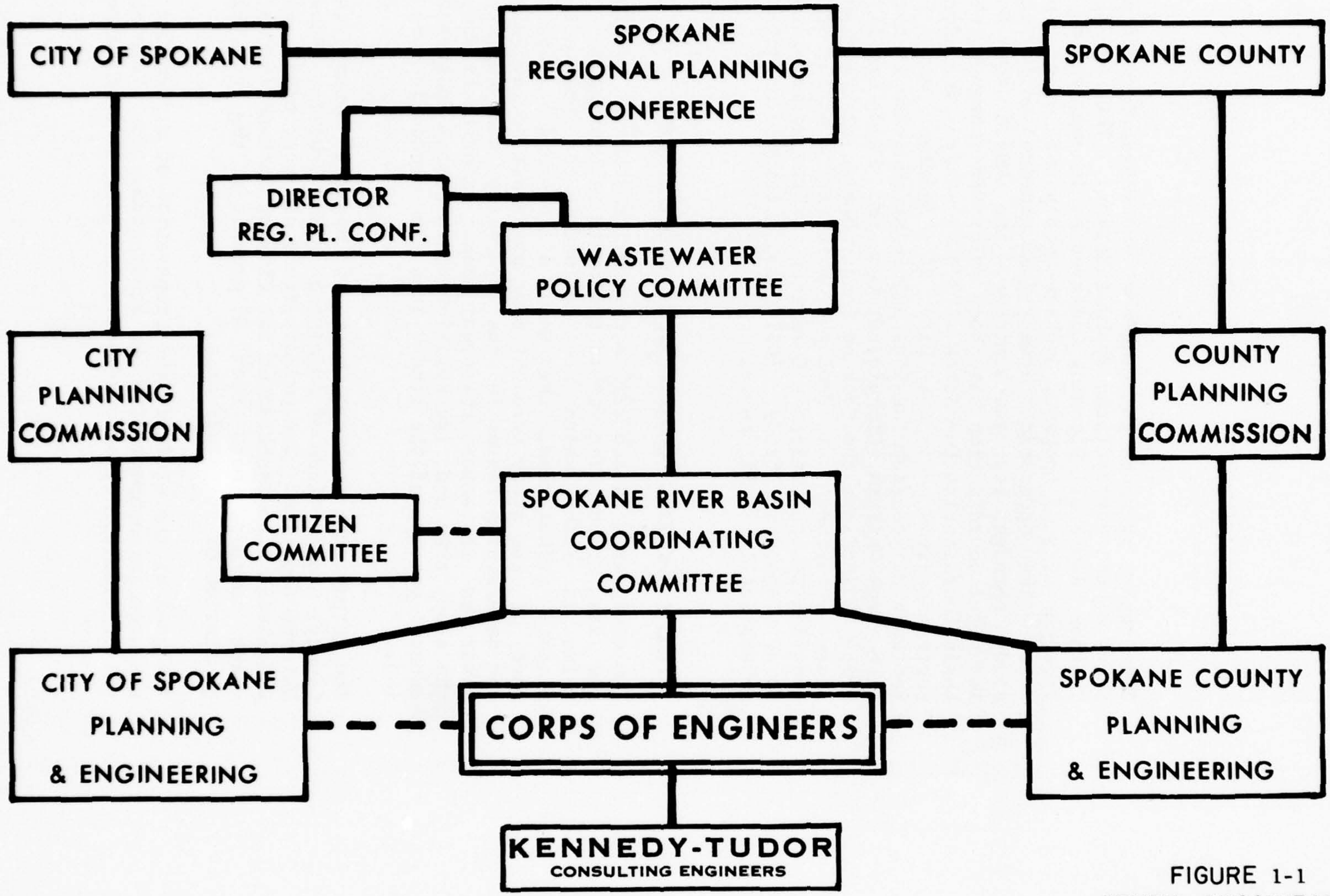
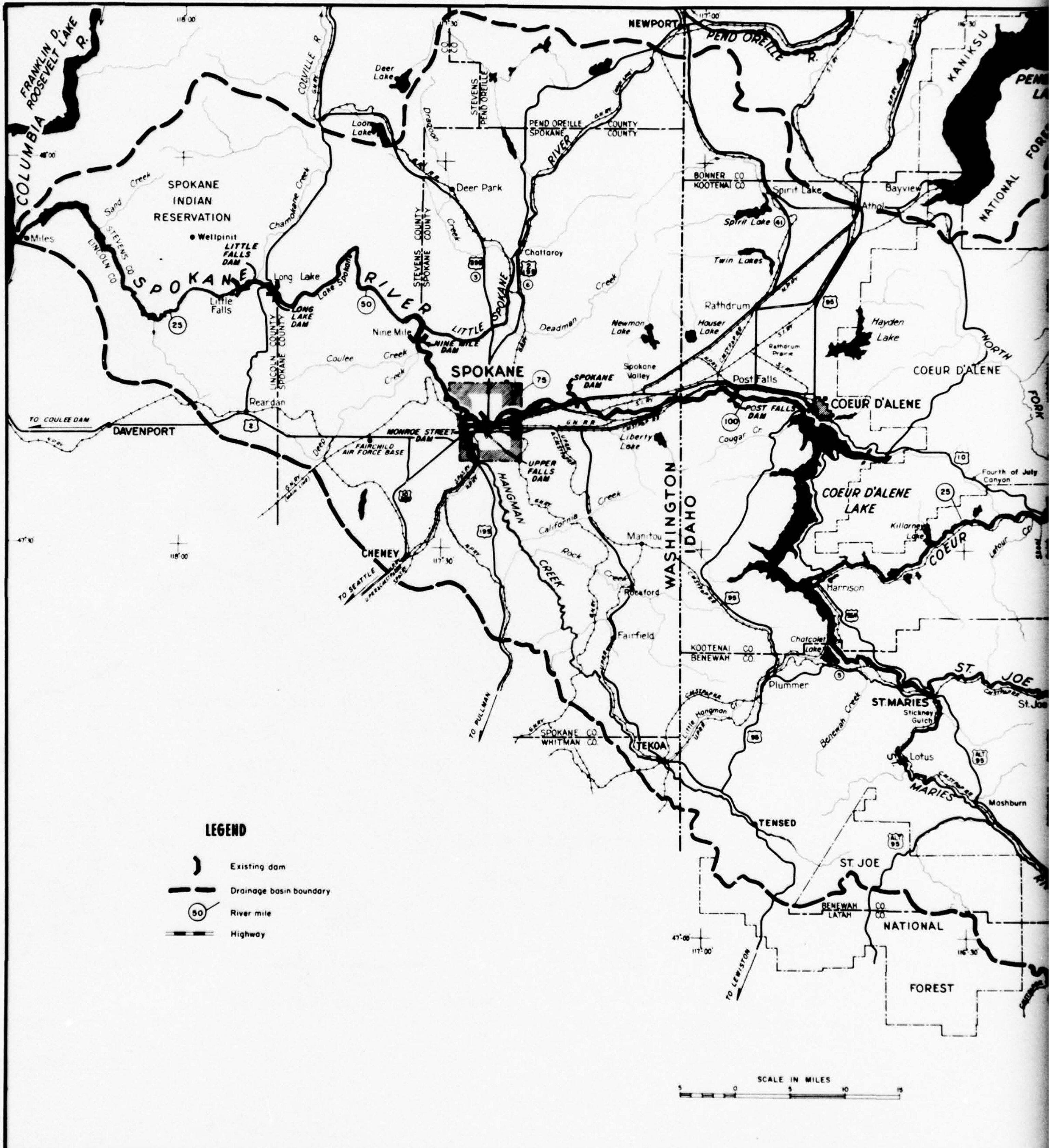


FIGURE 1-1
STUDY ORGANIZATION


FRANKLIN D. ROOSEVELT LAKE
COLUMBIA R.
SPOKANE INDIAN RESERVATION
Wellpinit
Sand Creek
Chamokane Creek
Miles
STEVENS CO.
LINCOLN CO.
LITTLE FALLS DAM
Long Lake
Little Falls
SPOKANE RIVER
Lake Spokane
LONG LAKE DAM
LINCOLN COUNTY
SPOKANE COUNTY
STEVENS COUNTY
SPOKANE COUNTY
Nine Mile
NINE MILE DAM
Coulee Creek
Deep Creek
Reardan
TO COULEE DAM
DAVENPORT
SPOKANE
SPOKANE DAM
MONROE STREET DAM
FAIRCHILD AIR FORCE BASE
UPPER FALLS DAM
HANGMAN CREEK
California Creek
Rock Creek
CHENEY
TO SEATTLE
TO PULLMAN
Deer Lake
Loon Lake
COLVILLE R.
Dragoon Creek
STEVENS
PEND OREILLE
Deer Park
Chattaroy
LITTLE SPOKANE
Deadman Creek
PEND OREILLE COUNTY
SPOKANE COUNTY
RIVER
NEWPORT
PEND OREILLE R.
BONNER CO.
KOOTENAI CO.
Spirit Lake
Twin Lakes
Rathdrum
Rathdrum Prairie
Newman Lake
Hauser Lake
Spokane Valley
Post Falls
POST FALLS DAM
Liberty Lake
Cougar Cr.
Manitou
Rockford
Fairfield
WASHINGTON
IDAHO
Bayview
Athol
KANIKSU
NATIONAL
Hayden Lake
COEUR D'ALENE
NORTH FORK
COEUR D'ALENE
COEUR D'ALENE LAKE
Fourth of July Canyon
Killarney Lake
COEUR
Harrison
KOOTENAI CO.
BENEWAH CO.
Chatcolet Lake
Plummer
ST. MARIES
Stickney Gulch
ST. JOE
St. Joe
Benewah Creek
Lotus
MARIES
Mashburn
SPOKANE CO.
WHITMAN CO.
TEKOA
Little Hangman Cr.
TENSED
ST. JOE
BENEWAH CO.
LATAH CO.
NATIONAL
FOREST
TO LEWISTON
LEGEND
Existing dam
Drainage basin boundary
River mile
Highway
SCALE IN MILES
5 0 5 10 15

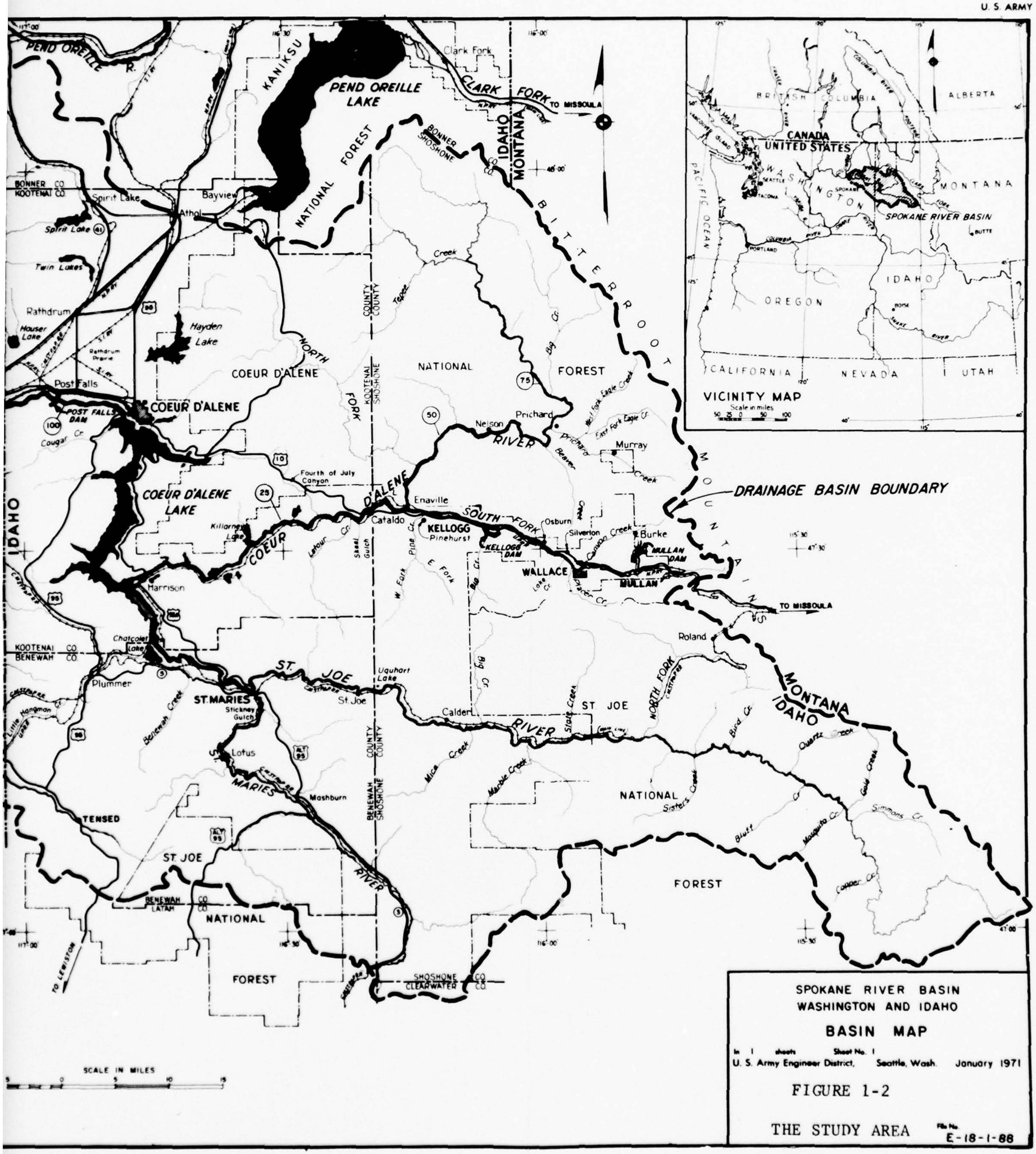


FIGURE 1-2

THE STUDY AREA

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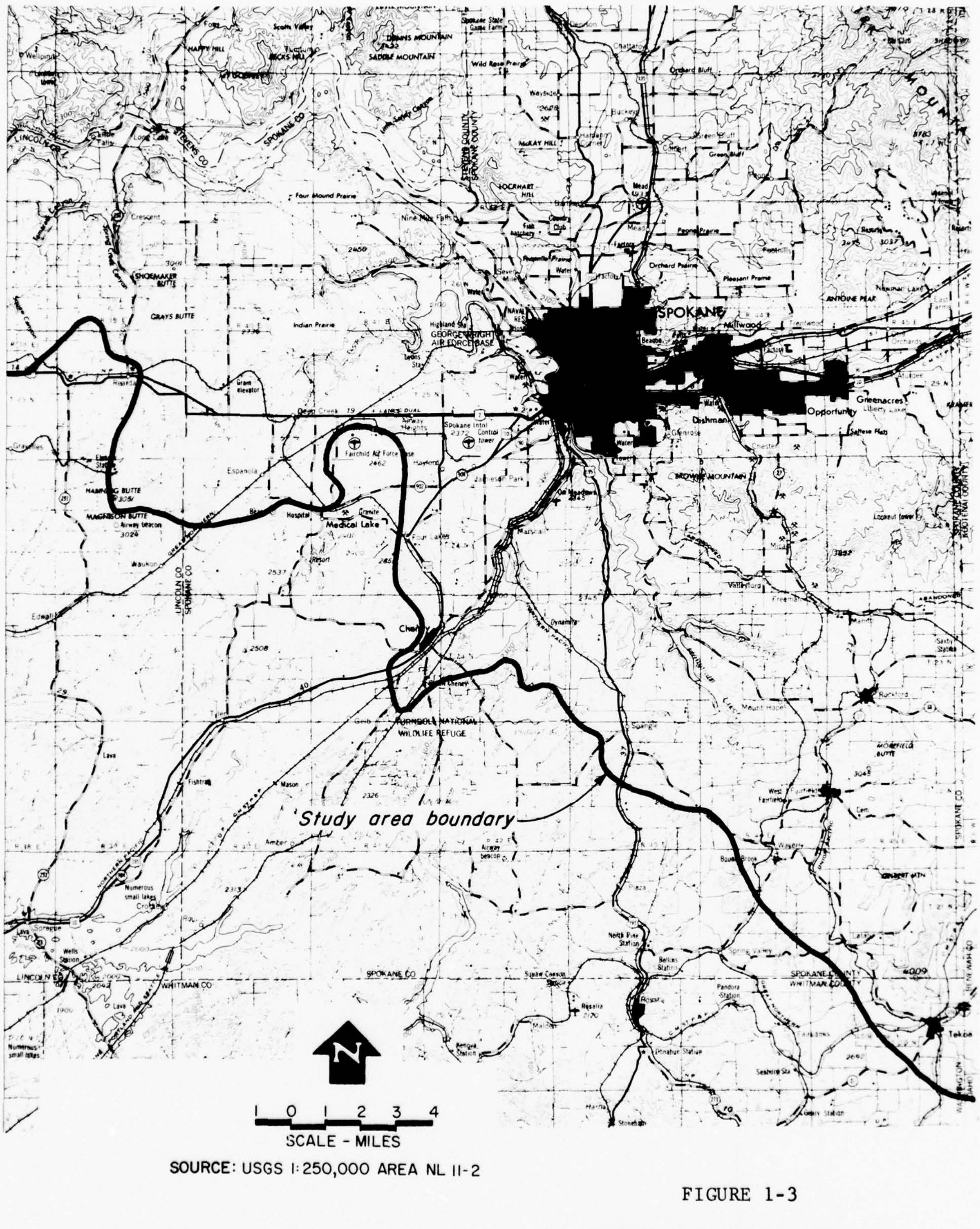


FIGURE 1-3

CENTRAL PORTION OF STUDY AREA

and analysis covering the full spectrum of water resource management. The goals of water resource management are the conservation and protection of water resources through optimum allocation of use for the benefit of man and his environment while providing for the protection or enhancement of the quality of the region's surface and groundwaters. An implied charge in responding to these broad goals is the task of ascertaining the most critical and significant unmet needs of this specific study area pertaining to water resources.

A major requirement of this study is the compilation of the basic data on the study area to make available the necessary facts from which needs can be determined and alternative solutions formulated. It is not the purpose of this report to summarize or abstract the results of the data gathering phase of the study except as necessary to provide a setting in which the analysis and results are understandable. The data gathering phase is documented in detail separately from this report, as described in Section 16. An overview of the study area is provided herein which describes the setting for subsequent analysis.

A second major requirement is evaluation of projected conditions. Forecast land use and populations are to be estimated to year 2000. As for basic data, the detailed analysis is documented elsewhere, as indicated in Appendix I, with salient facts only summarized herein.

Analysis of the basic data for this specific study area, concurrent implementation programs and special planning studies suggest the emphasis required in this planning effort. Water supply in most of the urban planning area is uniquely abundant and of good quality so there is not a need for emphasis on development of new or improved urban water supply. There is a critical water supply problem in the area west of the City, but this problem is specifically addressed in a concurrent study by others (Black and Veatch, 1973). These facts suggest that emphasis be placed on efforts to protect this resource rather than to augment it.

Two of the most critical surface water quality problems in the study area are the subject of a current implementation program and a concurrent planning effort. The existing water quality problems caused by primary effluent discharged from the City Sewage Treatment Plant (STP) are not addressed in this study since there is a committed plan to upgrade the City STP to secondary treatment with phosphorus removal. This study accepts the committed improvements as a given condition and addresses the water quality management problem as it will be when the committed improvements are complete. There is a significant water quality problem associated with overflows from the combined sewer system of the City that will not be corrected by the proposed improvements to the City STP. The City is, however, committed to a plan of study directed toward a stepwise correction of these deficiencies so that there is no need for a duplicate effort in this study.

Other concurrent studies regarding City wastewater concerns which impact the detail and focus of effort in this study are those on infiltration-inflow (Bovay 1974a), cost recovery (Bovay 1974b) and sludge disposal (Bovay 1975).

Given the above described constraints and the specific needs of the study area, the areas of wastewater management calling for emphasis in this study are:

1. Development of a regional wastewater management plan for the urban area.

2. Development of a regional plan for sewage solids disposal.

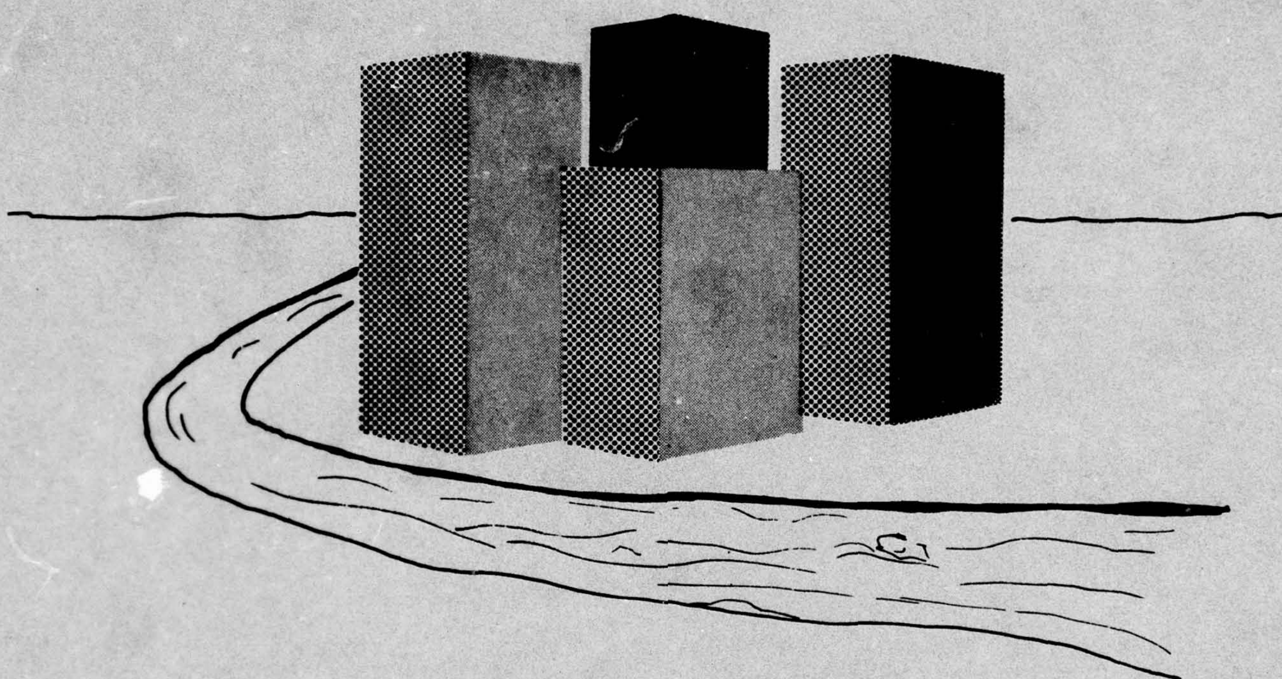
3. Development of implementation plans for the suggested regional wastewater and sewage solids disposal systems including institutional arrangements and financial plans.

4. Identification and evaluation of the needs for abatement of urban runoff pollution and flooding and consideration of possible alternative solutions.

5. Identification and evaluation of the needs for correction of flood control problems and development and evaluation of alternative corrective measures.

Because the stated goal of PL 92-500 is to further upgrade disposal standards beyond the specified 1983 requirement, it is one of the objectives of this study to consider the implications of future upgrade of standards on regional wastewater plan selection. The selected plan should be optimum not only to meet 1983 standards but provide optimum conditions for future upgrade to meet more severe projected standards.

A specific requirement of the study is the development of a mathematical model capable of simulation of surface water quality responses to various point source pollutional inputs. A brief description of the model simulation results and their significance are included in this report.



SECTION 2

THE SETTING

2. The Setting

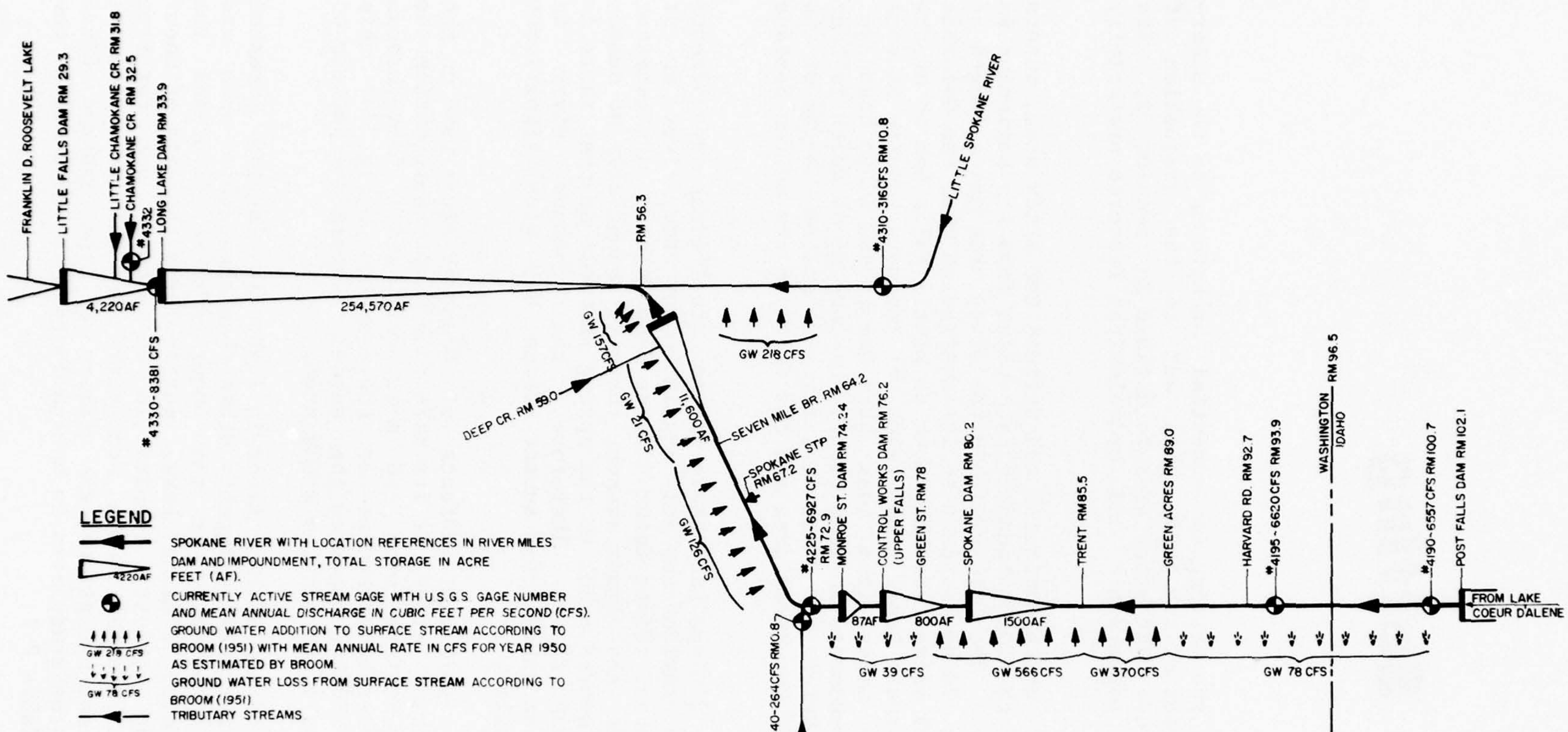
An understanding of the setting is essential background to the understanding of the needs of the study area and to the evaluation of planning alternatives. The study area is defined in Section 1. Its unique geological, topographic and hydrological features are briefly outlined below.

The Spokane River, which dominates and defines the study area, enters the study area at the Idaho boundary 14.6 miles from its beginning in Coeur d'Alene Lake. The river within the study area has a length of 96.5 miles from the Idaho boundary to its confluence with the Columbia River. The lower 29 miles from the mouth to Little Falls Dam is an arm of Franklin D. Roosevelt Lake. The reach of primary concern in this study is the 62.6 miles from Long Lake Dam to the Idaho boundary. There are four impoundments in this reach, the longest of which is Long Lake, 22.4 miles. Refer to Figure 2-1 for a schematic diagram of the principal streams of the study area and the impoundments on the Spokane River.

Upstream from Coeur d'Alene Lake there are no significant impoundments so that this lake provides the only regulation of the river as it enters the study area. Since Coeur d'Alene Lake is held at constant elevation throughout the summer season, there is essentially no summer regulation; it is lowered prior to the spring snowmelt so that there is attenuation of peak flows. Therefore, the Spokane River is characterized as an unregulated summer stream but with significant winter peak attenuation.

One of the most significant effects of Coeur d'Alene Lake on the quality of the Spokane River is its effect on temperature during the summer. The large surface area and relatively small flow-through result in high summer temperatures at the surface outlet of this natural lake. Table 2-1 summarizes the annual temperature pattern of the Spokane River as it enters the study area.

The tributary area of the Spokane River in Idaho is largely forested mountains. The water quality impacts other than the natural ones are due to the mining activity on the Coeur d'Alene River and the population around Coeur d'Alene Lake, particularly the city of Coeur d'Alene. The mining activity results in an unusual but far from critical zinc level and the human occupancy causes come bacterial pollution. With these exceptions, the quality of the Spokane River water as it enters the study area is unusually good as indicated by the analysis shown in Table 2-1.



NOTE: Figures for evaporation losses are not included.

FIGURE 2-1

SCHEMATIC DIAGRAM OF STUDY AREA STREAMS

TABLE 2-1

SPOKANE RIVER WATER QUALITY
ENTERING THE STUDY AREA

Parameter	Units	MEAN VALUES AT STATELINE RM 96.5			
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Temperature	°C	4.2	9.8	19.4	8.5
Dissolved oxygen	mg/l	12.6	11.1	9.0	10.2
B.O.D.	mg/l	1.4	3.3	1.3	1.0
Total phosphorus -P	mg/l	0.013	0.011	0.008	0.010
Ammonia -N	mg/l	0.066	0.108	0.088	0.029
Total N	mg/l	0.279	0.143	0.326	0.192
Total coliforms	No./100 ml	868	177	2002	986
Zinc	ug/l	241	248	168	261

There are two primary impacts of man's activity on the Spokane River inside the study area: the construction of a series of impoundments for hydroelectric power generation and the pollutional load of surface water disposals from the City and several industrial sources. The pollutional impacts are discussed in detail later. The impoundments are described briefly here as elements of the setting in which the pollutional impacts take place. Table 2-2 summarizes flow characteristics of the main streams.

The Spokane River is free flowing for less than half its length between the Idaho boundary and Long Lake Dam. The longest free-flowing reach is from the Idaho boundary approximately 12 miles to the impoundment behind Spokane Dam which provides the hydroelectric power to operate the City water supply system. This reach is through the Spokane Valley in a well defined channel. This section supports a rainbow trout population but is otherwise largely neglected as a recreational or aesthetic element despite its essentially natural free-flowing condition and absence of significant pollution. Spokane Dam is at the east boundary of the City and there are two more dams and the falls between this point and the confluence with Hangman Creek. This section of the river is not used significantly for recreation but is an important aesthetic element through the heart of the City. The three dams in this reach have relatively small impoundments which are operated primarily to create head on the turbines rather than to store water. The largest of these impoundments within the City is that formed by Spokane Dam, which is only 1500 acre feet in capacity, so that the exchange rate at minimum summer flow is more than once per day.

Below Monroe Street Dam the river is free flowing again for approximately ten miles to the backwater from Nine Mile Dam. The canyon of the Spokane River here forms the western edge of the City and a significant scenic element and supports a brown trout fishery. The

TABLE 2-2

FLOW CHARACTERISTICS OF MAIN STREAMS
OF THE STUDY AREA

Gaging Station[1] (Period of Record)	ITEMS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Spokane River at Spokane Wash. (1892 1972)	Max	25,426	16,416	25,380	23,806	29,386	29,900	11,900	4,740	3,300	5,640	13,100	22,906
	Min	1,336	1,486	2,046	4,257	6,820	3,112	1,356	908	1,152	1,300	1,147	1,700
	Mean	5,497	6,082	8,072	14,747	19,069	11,743	3,653	1,916	1,767	2,150	3,374	5,110
Little Spokane River at Dartford, Wash. (1929 1972)	Max	616	1,108	1,211	1,301	1,176	710	331	193	175	234	311	353
	Min	99.6	160	167	170	132	98.2	80.3	67.8	80.3	87.9	113	122
	Mean	276	430	577	692	461	272	168	136	143	164	193	230
Little Spokane River at Elk, Wash. (1949 1971)	Max	69.7	107	110	137	98.7	78.6	64.7	54.0	52.2	56.9	61.2	61.3
	Min	38.6	44.6	47.1	47.2	43.4	38.8	35.4	35.5	35.5	37.0	39.2	4.09
	Mean	51.5	60.2	69.8	83.9	72.5	59.7	49.5	44.7	44.3	45.3	47.1	49.2
Hangman Creek at Spokane, Wash. (1948 1972)	Max	1,574	1,681	1,914	928	1,925	391	37.8	38.1	26.5	32.4	188	1,251
	Min	33.7	225	132	66.8	32.9	15	3.45	2.81	4.06	7.89	15.9	35.7
	Mean	494	803	821	401	250	95.3	22	13.4	13.9	18.4	44.7	197
Spokane River near Post Falls, Idaho (1913 1971)	Max	24,930	16,340	17,110	26,050	31,800	25,600	10,700	2,130	1,840	5,460	13,100	23,660
	Min	996	1,020	1,750	6,819	6,620	1,580	914	184	188	782	667	784
	Mean	5,132	5,963	7,430	14,977	22,039	9.829	1,985	931	1,055	1,682	2,927	4,731
Spokane River at Long Lake, Wash. (1940 1972)	Max	16,430	19,500	21,530	29,410	33,520	25,650	7,951	3,178	3,122	4,327	9,065	15,820
	Min	2,991	4,664	3,966	5,573	7,049	3,932	1,942	1,424	1,476	1,868	2,059	2,341
	Mean	7,011	8,934	10,380	16,498	20,887	12,499	4,571	2,661	2,788	3,704	4,264	6,377
Spokane River above Liberty Bridge, Wash. (1958 1972)	Max	12,590	16,050	24,440	22,540	25,870	21,870	3,351	1,408	1,731	3,281	5,892	14,420
	Min	2,702	2,251	2,890	7,999	8,197	3,253	913	159	356	748	1,729	1,790
	Mean	5,355	8,110	8,710	14,645	18,643	11,074	1,685	690	1,070	1,713	3,241	4,760

[1] Compiled from USGS records for the gages and period of record indicated

discharge of the City STP is about two-thirds of the way down this reach and upstream from the portion which passes through the Riverside State Park and the particularly beautiful Bowl and Pitcher area. There is no fish population in this reach which at present receives the impact of the primary treated sewage effluent.

The impoundment at Nine Mile Dam is the second largest in the study area at 11,600 acre feet and the first downstream from the City outfall. The approximate exchange rate at mean summer flow conditions is six days.

The impoundment behind Long Lake Dam extends to the base of Nine Mile Dam and also a short distance upstream from the natural mouth of the Little Spokane River. This impoundment stores 254,570 acre feet at maximum water level 1536 feet, which is also normal pool for optimum power generation. The minimum pool for power generation is the crest gate sill of Long Lake Dam which is at 1508 feet elevation. The dead storage below that level is 149,500 acre feet. Exchange time at mean summer low flow (August 2661 cfs) is 48 days at normal pool and 28 days at minimum pool.

At present, Long Lake becomes strongly eutrophic in most summer seasons. Soltero et al (1975), after intensive investigations covering three years (1972, 1973 and 1974), conclude that although eutrophic conditions were observed each summer there was a significant degree of variability in the timing, density and composition of the biomass supported by the lake waters in each year. There is no significant algal growth during the winter season, approximately 1 November to 30 April, when water temperatures are usually below 10°C. The current Department of Ecology (DOE) requirement for year around phosphorus removal, which is to be provided by the committed upgrading of the City STP, is specifically directed at correcting the major algal blooms in Long Lake.

At present Long Lake supports a recreational fishery for large mouth bass and other spiny-rayed species. There is also a limited commercial harvest of the abundant carp and suckers. There are no state, county or city level recreation plans that propose future use of Long Lake as a significant recreation resource. There is some recent subdivision development overlooking Long Lake which appears to be the only present utilization of Long Lake as an aesthetic element. Washington Water Power Company (WWP) has plans for recreational facilities on company property including a boat launching ramp and day use facilities. In addition WWP is setting aside 200 acres for future recreational development. The lack of more ambitious plans to utilize the recreational potential of Long Lake is probably due to two causes: one, the present state of eutrophication and two, the nearby availability of alternative recreation areas in Pend Oreille County and in Idaho.

Of equal or greater significance to the urban area than the Spokane River is the underground river which enters the study area from Idaho, flowing through the glacial outwash gravels which fill the ancient valley of the Spokane River. This underground river originates in the Rathdrum Prairie of Idaho where it is believed to be fed from a variety of sources including Lake Pend Oreille and the surrounding mountain slopes. The volume and quality of the flow and the high permeability of the aquifer are unique. The entering flow is estimated at 1000 cfs. The quality is exemplified by the analysis shown in Table 2-3.

The glacial outwash gravels which form this unique geological feature underlie an L-shaped area extending from the Idaho boundary westward 16 miles to and under the City where the formation turns northward continuing under the City 6 miles to the valley of the Little Spokane River. Refer to Figure 2-2 for mapping of the aquifer in the study area. The gravels fill the valley from side to side forming the relatively level valley floor. The total depth of the gravels is not known since the abundance of water obtainable with shallow penetrations of the water table makes deeper exploration unnecessary. The depth from ground surface to the water table varies from approximately 110 feet at the Idaho boundary to a minimum of approximately 40 feet near the eastern city limits, then increases to 120 feet or more in the northern part of the City before emerging as springs along the Little Spokane River.

This aquifer supplies the entire domestic, irrigation and industrial water supply of the urban area with the exception of one surface water diversion for industrial cooling. The diversions from the aquifer for man's use are estimated to total approximately 178 cfs, the remainder and largest part continuing to their natural outlets into the Spokane and Little Spokane Rivers. These groundwater increments to both rivers have significant impacts on both flow volume and quality.

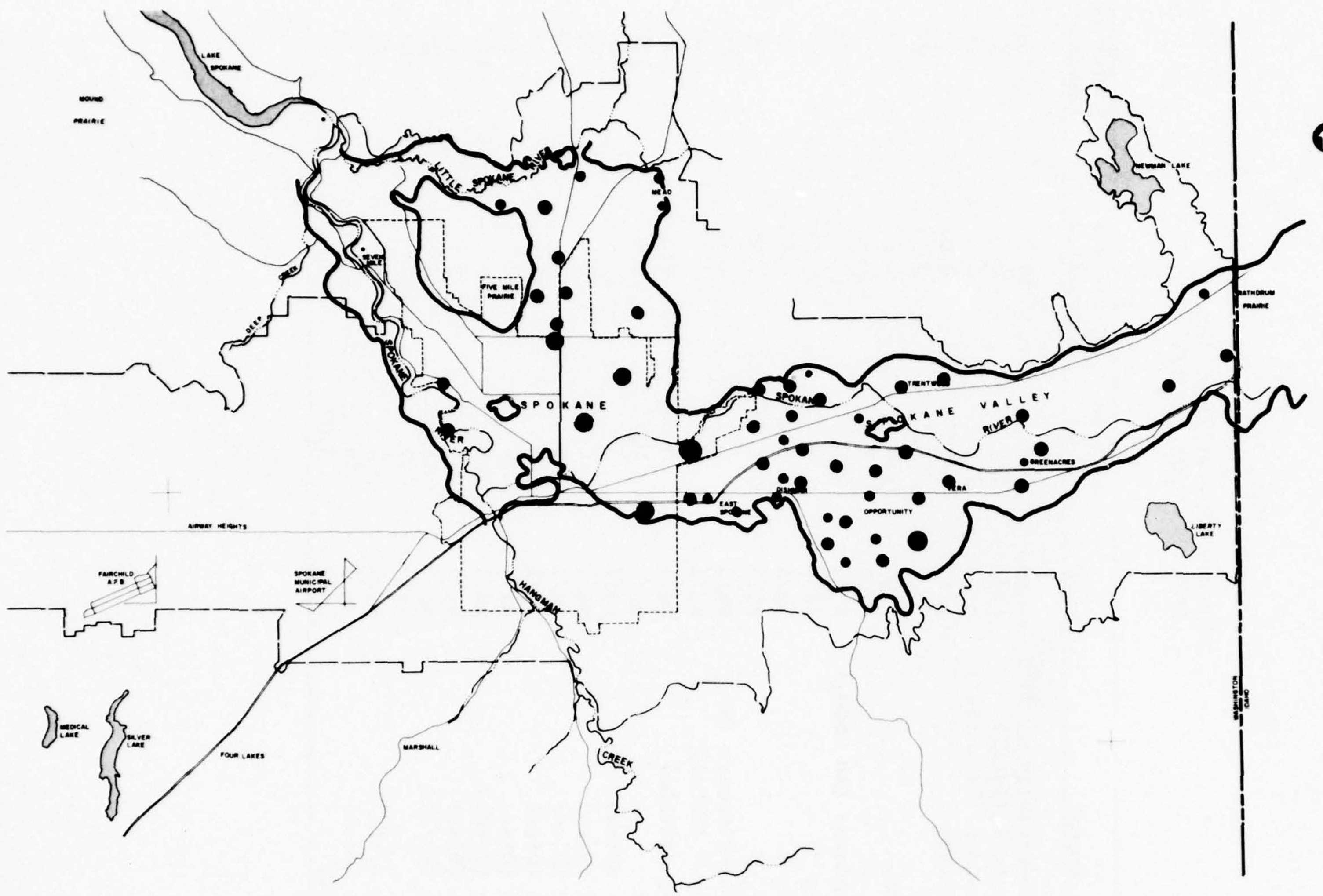
A volume estimated at approximately 500 cfs enters the Spokane River between the Idaho boundary and the city limits and makes up between one-third and one-fourth of river flow in late summer. The groundwater, with a year around temperature of 11°C (52°F), significantly moderates the high surface water temperature. A groundwater volume estimated at 200 cfs enters the lower reaches of the Little Spokane River where it forms over 50 percent of the summer flow. Thus the Spokane River below the Little Spokane River confluence has benefited by the addition of over 700 cfs of groundwater representing approximately 25 percent of the late summer flow into Long Lake. The importance of this major groundwater flow to both the human occupancy of the area and to the natural environment cannot be overemphasized.

The other major hydrologic elements of the study area are Hangman Creek and the Little Spokane River. These two streams with mean

TABLE 2-3

GROUNDWATER QUALITY OF THE SPOKANE VALLEY AQUIFER

Parameter	Units	Average Value	Standard Deviation	Number of Samples
Conductivity at 25°C	μmhos	285	56	201
Residue (Total)	mg/l	177	46	150
Residue (Diss-180°)	mg/l	171	26	49
Residue	TON/AFT	0.23	0.04	48
pH	-	7.7	0.6	198
Temp.	°C	10.7	1.8	69
D. O.	mg/l	8.3	1.4	5
Hardness (As $CaCO_3$)	mg/l	157	40	202
NH_3 -N	mg/l	0.015	0.008	49
NO_2-N	mg/l	0.002	0.002	49
NO_3-N	mg/l	1.521	1.258	50
Kjel-Nitrogen (N)	mg/l	0.111	0.146	49
PO_4-P (Total)	mg/l	0.014	0.012	50
PO_4-P(Ortho)	mg/l	0.010	0.012	49
Cl	mg/l	4.7	3.6	198
As (Diss)	μg/l	5	10	49
Cd (Diss)	μg/l	0	0	49
Cr (Diss)	μg/l	0	0	49
Cu (Diss)	μg/l	6	11	49
Fe (Diss)	μg/l	28	32	49
Fe (Total)	μg/l	169	356	146
Pb (Diss)	μg/l	2	3	43
Pb (Total)	μg/l	19	8	20
Mn	μg/l	7	10	201
Hg (Total)	μg/l	2	4	61
Zn (Diss)	μg/l	26	32	50
MBAS	mg/l	0.02	0.03	45



LEGEND

● DOMESTIC WATER SUPPLY

— PRINCIPLE AQUIFER BOUNDARY

FIGURE 2-2
SPOKANE VALLEY AQUIFER

annual discharges of 264 cfs and 316 cfs[1/] respectively together total less than 7 percent of the total mean annual flow of the Spokane River at Long Lake. The mean annual flow patterns of the Spokane River, Little Spokane River and Hangman Creek are compared in Figure 2-3

Hangman Creek (also known as Latah Creek) drains an area that is predominantly dry farmed in wheat on Palouse soils with rolling topography. These soils provide essentially no groundwater to sustain flow when there is no precipitation or snowmelt. Also, there are no manmade impoundments. The net result is a stream characterized by extremes. The maximum measured discharge is 20,600 cfs, the minimum 2.3 cfs and the mean 264 cfs. The other significant characteristic of Hangman Creek is the heavy silt load resulting from the combination of crop, agricultural practices, topography and the Palouse soils. Essentially no beneficial use is made of Hangman Creek flows before they join the Spokane River. Man's primary impact on Hangman Creek has been the creation of a severe erosion problem through his agricultural operations.

The Little Spokane River drains a more heterogeneous area than Hangman Creek and is entirely different in character. The upland areas are forested granitic mountains. The lowlands are dominated by pasture and forage croplands on the alluvial filled valley floor. This watershed is characterized by a large groundwater interchange with the surface flows. The resultant streamflow is exceptionally stable with well sustained low flows and without sudden and high peak flows. The Little Spokane River, with essentially the same number of square miles of tributary area as Hangman Creek, has a maximum measured discharge of only 3170 cfs, a minimum of 63 cfs and a mean of 316 cfs. Extensive use is made of its surface waters for irrigation but there are no significant municipal supplies from surface sources. There is no significant siltation problem for the watershed as a whole. Man's impact on the Little Spokane, other than diversion of surface waters for irrigation, have been relatively minor. There are no manmade impoundments or channel alterations. Extensive removal of trees along streams in agricultural areas has altered the fish habitat.

The human occupancy of the study area is concentrated in one urbanizing metropolitan area with contiguous elements. The City occupies a site approximately 5.5 miles by 7 miles straddling the Spokane River north and south, immediately upstream from its confluence with Hangman Creek. Hangman Creek and the continuation of the Spokane River form the western limits of the City. Except for the southernmost part, the City is located almost entirely on the surface of the gravel fill of the Spokane Valley. The largest part of the City is between elevations 1900 and 2100 feet. The present City population is

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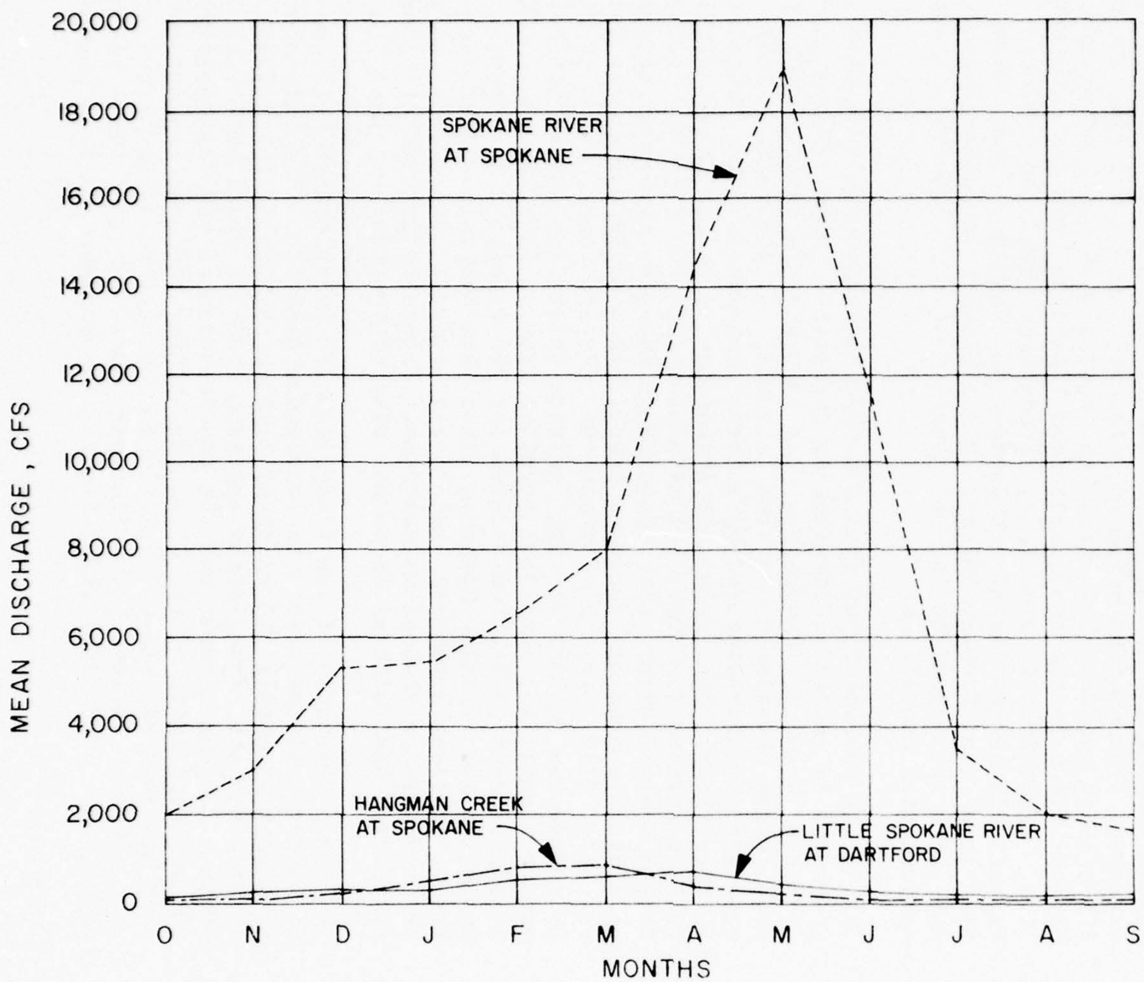
[1/] Exclusive of the groundwater increment.



SPOKANE RIVER	
MAX. MONTH	29,900 CFS
MAX. YEAR	10,361 CFS
MEAN ANNUAL	6,927 CFS
MIN. MONTH	908 CFS
MIN. YEAR	2,974 CFS
DRAINAGE AREA	4,290 SQ. MI.
MEAN ANNUAL RUNOFF	21.92 INCHES

HANGMAN CREEK	
MAX. MONTH	1,925 CFS
MAX. YEAR	432 CFS
MEAN ANNUAL	264 CFS
MIN. MONTH	2.81 CFS
MIN. YEAR	111 CFS
DRAINAGE AREA	689 SQ. MI.
MEAN ANNUAL RUNOFF	5.2 INCHES

LITTLE SPOKANE RIVER	
MAX. MONTH	1,301 CFS
MAX. YEAR	443 CFS
MEAN ANNUAL	316 CFS
MIN. MONTH	67.8 CFS
MIN. YEAR	128 CFS
DRAINAGE AREA	665 SQ. MI.
MEAN ANNUAL RUNOFF	6.45 INCHES

FIGURE 2-3

MEAN ANNUAL FLOW
PRINCIPAL STUDY AREA STREAMS

approximately 174,000 and the lands within the present city limits are well filled with predominantly single family residential development. The City area is supplied with water from an integrated water system owned and operated by the City and supplied from wells penetrating the Spokane Valley aquifer near the east boundary of the City. The City area is almost entirely served by a community sewage collection system, mostly of the combined type, and a treatment plant located on and discharging to the Spokane River.

There are two contiguous areas that are presently developed to densities that characterize them as urban. These areas adjoin the City on the north and on the east. The area to the north is presently occupied by approximately 20,000 persons outside the city limits. The unincorporated areas north of the City are provided water service by a number of separate water companies supplied from wells in the Spokane Valley aquifer. The North Spokane area, that area generally north of Francis Avenue both unincorporated and within the city limits, is not served by a single community sewage collection system. The area north of Francis Avenue slopes away from the area served by the City system south of Francis Avenue. The North Spokane area presently has a mixture of separated sewered areas with separate disposal facilities and on-site (septic tank) disposal. The North Spokane area has developed in typical subdivision manner as groups of relatively high density single family residences.

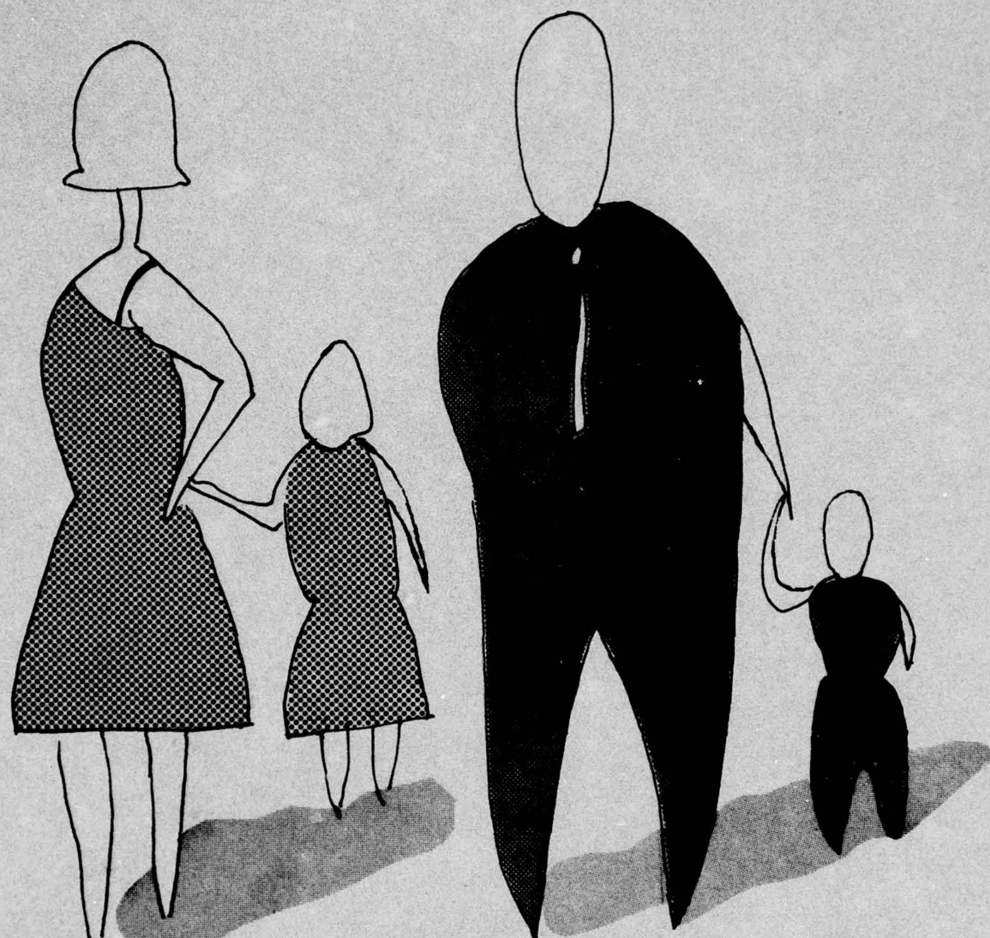
The contiguous suburbs east of the City are usually referred to collectively as Spokane Valley. Unlike North Spokane this area developed on an agricultural base. There are approximately 60,000 persons in the whole valley extending to the Idaho boundary but urban type development essentially ends at Sullivan Road approximately 7 miles east of the east city limit. The area was once occupied by irrigated agriculture and the relatively level valley floor was basically divided along section and subsection lines. The area still gets its water supply from a number of irrigation districts that developed originally to serve agriculture. All of the water supplies are from wells in the Spokane Valley aquifer. Much of the development has followed the pattern of the original rectilinear agricultural boundaries resulting in relatively low overall densities. The more recent development, farther from the City, is more typically by planned subdivisions and at a higher overall density. None of the area east of the city limits is served by a community sewer system except for the commercial section of Millwood. Essentially the entire Spokane Valley relies upon on-site (septic tank) sewage disposal.

It is most significant that almost all the suburban development is confined to the surface of the glacial outwash gravels both in North Spokane and in Spokane Valley. This geological formation provides access to a water supply at shallow depth and the highly permeable character at the surface accepts drainfield effluent with little expectation of surfacing. The primary difference between North Spokane and Spokane Valley is that the soil materials in North Spokane

are finer so that septic tanks there have not been as universally successful as in the Spokane Valley.

Human occupancy throughout the remaining area surrounding the City is scattered at a low nonurban density. There is a strong correlation between the availability of an abundant water supply, soils suitable for on-site disposal and the amount of development. West of the Spokane River, the Columbia Plateau begins and the area is underlain with basalt. The water supply from the basalt aquifer is neither abundant nor certain at any location. The mantle of soil on the basalt is variable in both thickness and permeability. These constraints along with rather stark surroundings have discouraged urban expansion west of the Spokane River. East and northeast of the City the surroundings are more attractive in Pleasant, Orchard and Peone Prairies but there is at present no urban development. Lack of an abundant water supply is a strong constraint. The City water system, adjacent to the area southwest of the City in Moran Prairie, is a potential source for an imported supply, but the area is topographically not tributary to the City sewage collection system and has marginal soil conditions for on-site disposal. Here, lack of easy sewage disposal appears to be the constraint. Similar conditions exist in and adjacent to the southwest corner of the City where the Columbia Plateau conditions are encountered.

The study area outside the urbanizing area is characterized by a few isolated communities and low density scattered populations. The present population of the City and its immediate suburbs including North Spokane, Spokane Valley and Fairchild AFB is approximately 275,000. There are approximately 33,000 persons in the remainder of the study area of which 14,000 are in incorporated towns and 19,000 in rural areas. The study area total is 308,000 persons. Less than 5000 are outside Spokane County.



SECTION 3

PROJECTED GROWTH

3. Projected Growth

Population

Population projections for the study area and its subdivisions are derived from consideration of a number of sources and factors. The fundamental elements are projected control totals for each county having land in the study area. The control totals are derived from consideration of projections developed by the State of Washington, Pacific Northwest Bell, the Bonneville Power Administration, the Federal Office of Economic and Business Research (OBERS) and analysis of employment and economic trends in Spokane County. The selected projected population control totals by counties to year 2020 are shown in Table 3-1.

TABLE 3-1

CONTROL TOTALS - PROJECTED COUNTY POPULATIONS[1]

County	Years								
	1970	1975	1980	1985	1990	1995	2000	2010	2020
Spokane	287,500	309,300	324,600	340,000	356,700	373,400	390,000	420,000	450,000
Lincoln	9,600	9,100	8,900	8,600	8,400	8,100	7,900	7,800	7,700
Pend Oreille	6,000	5,700	5,300	5,200	5,000	4,800	4,600	4,800	5,000
Stevens	17,400	17,400	17,300	17,300	17,500	17,700	17,900	18,300	18,600
Whitman	37,900	40,900	41,900	41,900	41,900	42,100	43,700	44,600	45,500

[1]For counties as a whole, not limited to portions in the study area.

Present population distribution within the various counties as indicated by census tract totals provides a basis for allocation of projected control totals. Results presented in Table 3-2 show a breakdown for the study area as a whole including detail outside the urbanizing area and a total for the urbanizing area. The split of the control totals between urbanization and rural areas is based on the assumed continuation of the historical split in the ratio of 90 percent in the urbanizing area and 10 percent in the rural area.

TABLE 3-2

PROJECTED POPULATIONS OF THE STUDY AREA

	1970	1975	1980	1985	1990	1995	2000	2010	2020
Urbanizing Area	258,102	275,000	291,706	306,007	320,993	335,999	351,001	378,000	404,980
Incorporated Towns									
Cheney	6,358	6,820	7,313	7,844	8,412	9,022	9,676	11,130	12,802
Deer Park	1,295	1,500	1,559	1,622	1,687	1,754	1,824	1,973	2,134
Fairfield	469	495	547	605	668	738	816	996	1,216
Latah	169	158	148	138	129	121	113	99	86
Medical Lake	3,529	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Rockford	327	367	367	367	367	367	367	367	367
Spangle	179	200	200	200	200	200	200	200	200
Waverly	48	61	61	61	61	61	61	61	61
Subtotal-Spokane Co.	12,374	13,101	13,695	14,337	15,024	15,763	16,557	18,326	20,366
Tekoa	808	900	900	900	900	900	900	900	900
Subtotal in Whitman Co.	808	900	900	900	900	900	900	900	900
Total Non-Rural Outside the Urban Planning Area	13,182	14,001	14,595	15,237	15,924	16,663	17,457	19,226	21,266
Rural Areas									
Lincoln Co.	413	391	383	370	361	348	340	336	331
Pend Oreille Co.	884	840	781	766	737	707	678	707	737
Spokane Co.	14,460	15,130	15,932	16,695	17,533	18,318	19,039	20,008	20,706
Stevens Co.	2,646	2,646	2,631	2,631	2,661	2,692	2,722	2,783	2,829
Whitman Co.	47	23	45	45	45	50	86	106	126
Subtotal Rural	18,450	19,030	19,772	20,507	21,337	22,115	22,865	23,940	24,729
TOTAL STUDY AREA	289,734	308,031	326,073	341,751	358,254	374,777	391,323	421,166	450,975
STUDY AREA TOTAL, ROUNDED	290,000	308,000	326,000	342,000	358,000	375,000	391,000	421,000	451,000

Detailed allocation of projected population in the urbanizing area is based on the allocation model developed by the Spokane Metropolitan Area Transportation Study (SMATS). The extremely fine areal breakdown for the SMATS study is not required for wastewater management planning. Therefore, the SMATS elements are aggregated into larger wastewater planning units selected to recognize topography as well as development. The wastewater planning units for the urban planning area are shown in Figure 3-1. The population projection in terms of these planning units is shown graphically for the major service areas in Figure 3-2 and is detailed in Tables 3-3, 3-4 and 3-5.

The population projections include, in addition to the "gross" population of each area, an estimated "served" population. The "served" population is intended to provide a realistic evaluation of that part of the total, or gross, population which could feasibly and economically be served by a community sewage collection system at that specific stage of development. The estimate of proportion "served" is derived from analysis of the existing development pattern in each area and an evaluation of how future growth will affect that pattern.

Analysis of the population projections for the urban planning area leads to the following conclusions regarding the growth pattern:

1. That part of the City within the present service area of the main sewage collection system is forecast to have less than 10 percent growth between 1980 and year 2020.

2. The North Spokane area, including some lands that are within the city limits, is forecast to have the highest growth rate in the urban planning area with an increase of 2.4 times from 1980 to year 2020.

3. Spokane Valley suburbs, although much larger than North Spokane, are forecast to grow at a lower rate, increasing 60 percent from 1980 to year 2020.

4. The only other adjoining areas forecast to have significant growth and to, in part, reach densities that can be classified as suburban are Moran Prairie and Southwest. Both of these areas are forecast to double in population between 1980 and 2000.

5. The West Plateau area is forecast to almost double in population but the present low level means that the future density will still be very low. This area is constrained by a presently inadequate water supply and its growth could change with any alterations in the water supply situation.

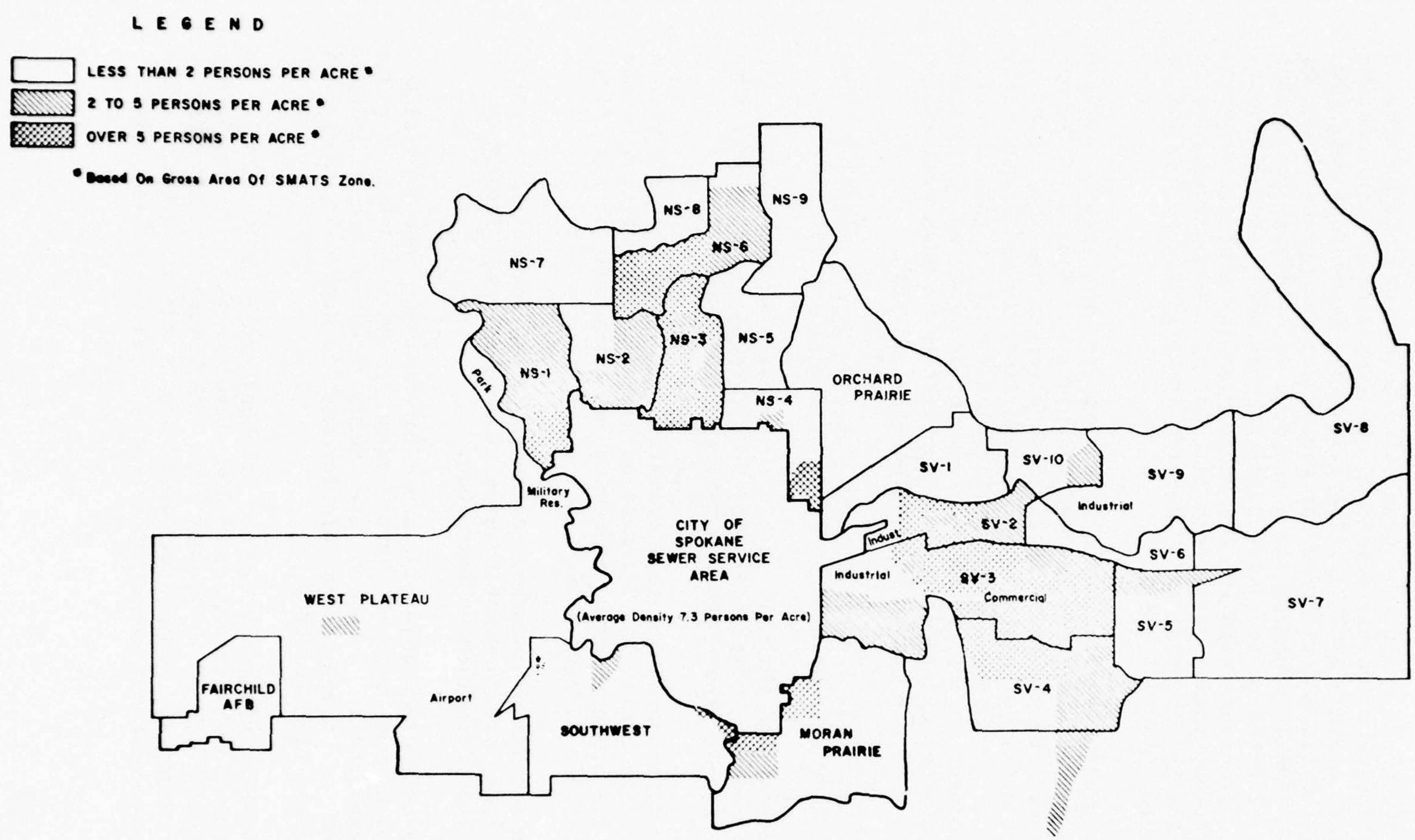
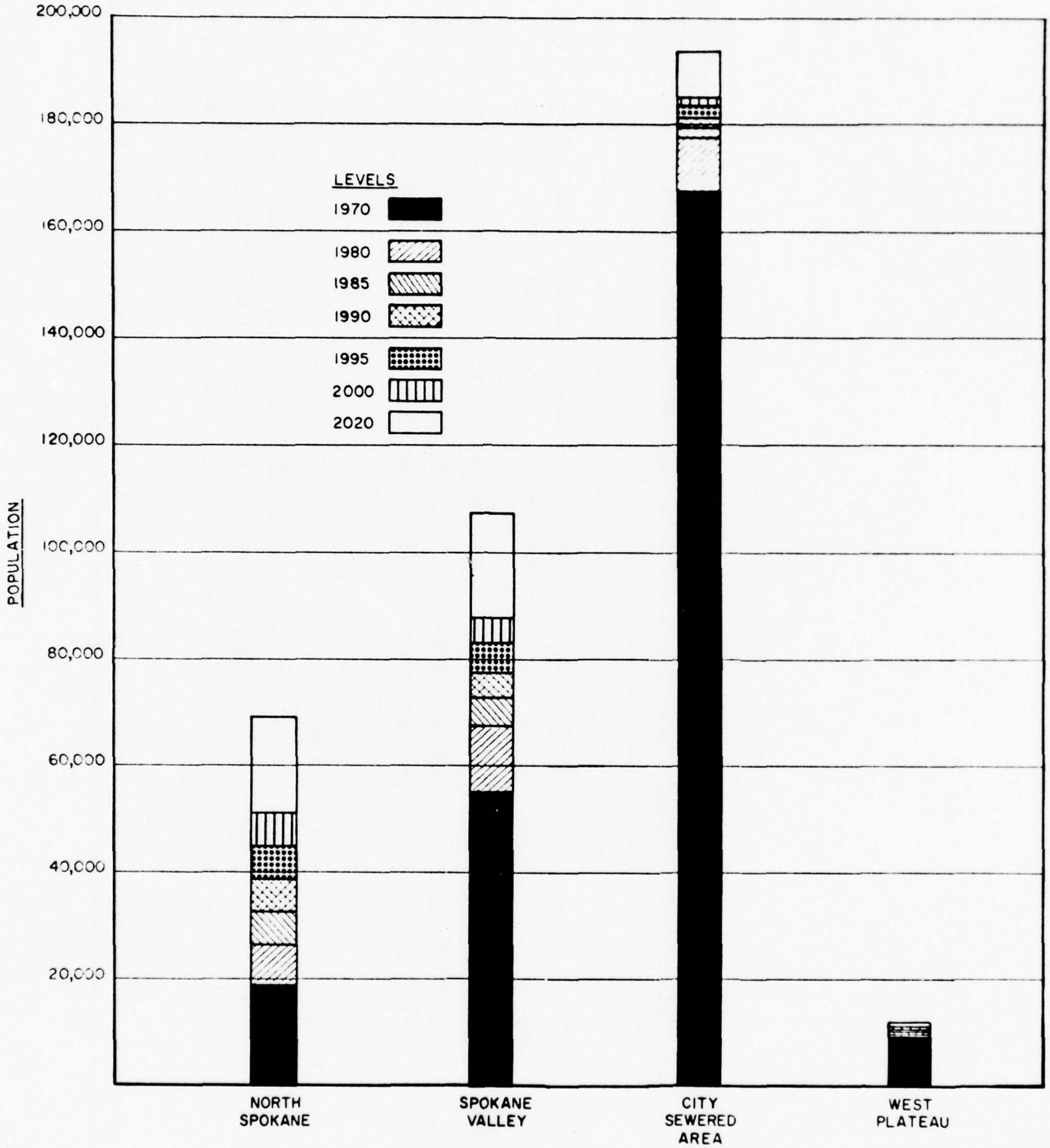


FIGURE 3-1
PLANNING UNITS AND FORECAST POPULATION DENSITIES



POPULATION GROWTH BY REGION

FIGURE 3-2

FORECAST POPULATION GROWTH BY MAJOR SERVICE AREAS

TABLE 3-3

FORECAST POPULATIONS OF SERVICE AREAS
SUMMARY

	1980		1985		1990		1995		2000		2020	
	Gross	Served	Gross	Served	Gross	Served	Gross	Served	Gross	Served	Gross	Served
City	177,660	174,107	179,101	175,519	180,639	177,026	182,328	178,681	184,073	180,392	192,962	191,032
Moran Prairie	5,530	3,097	6,404	3,714	7,320	4,392	8,307	5,515	9,298	7,438	12,949	11,007
South West	3,088	741	3,547	887	4,029	1,088	4,433	1,241	4,839	1,452	6,504	2,276
SUBTOTAL	186,278	177,945	189,052	180,120	191,988	182,506	195,068	185,437	198,210	189,282	212,415	204,315
Spokane Valley	69,304	52,227	74,533	57,737	79,963	63,166	85,334	69,154	90.585	74,061	111,356	91,021
North Spokane	26,171	17,220	32,215	19,818	38,561	29,433	44,786	36,080	51,062	44,627	68,485	62,482
SUBTOTAL	281,753	247,392	295,800	257,675	310,512	275,105	325,188	290,671	339,857	307,970	392,256	357,818
Orchard Prairie	645	-	674	-	707	-	747	-	787	-	940	-
West Plateau	2,608	1,807	2,833	1,993	3,074	2,187	3,364	2,401	3,657	2,614	5,084	3,532
Fairchild AFB	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700
SUBTOTAL	9,953	8,507	10,207	8,693	10,481	8,887	10,811	9,101	11,144	9,314	12,724	10,232
TOTAL	291,706	255,899	306,007	266,368	320,993	283,992	335,999	299,772	351,001	317,284	404,980	368,050
Newman Lake	162	147	311	286	468	435	630	592	792	752	1,493	1,418
Liberty Lake	982	953	1,164	1,141	1,356	1,342	1,467	1,467	1,580	1,580	2,097	2,097

TABLE 3-4

FORECAST POPULATIONS
NORTH SPOKANE SERVICE AREA

Subunits	1980 Gross	1980 Served	1985 Gross	1985 Served	1990 Gross	1990 Served	1995 Gross	1995 Served	2000 Gross	2000 Served	2020 Gross	2020 Served
NS-1	1,507	0	3,093	0	4,759	4,045	6,375	5,610	8,000	7,200	13,922	12,808
NS-2	896	0	1,666	0	2,474	1,484	3,282	2,462	4,097	3,073	7,189	6,111
NS-3	14,555	14,409	16,257	16,094	18,044	18,044	19,693	19,693	21,358	21,358	25,120	25,120
NS-4	2,754	1,377	2,785	1,392	2,818	1,409	2,863	1,432	2,910	1,455	3,146	2,202
NS-5	1,139	342	1,156	347	1,174	352	1,216	426	1,261	504	1,437	647
NS-6	2,730	1,092	4,411	1,985	6,177	4,015	7,919	6,335	9,670	8,413	12,669	12,036
NS-7	165	0	187	0	209	84	243	122	277	152	397	238
NS-8	312	0	374	0	441	0	509	0	579	290	887	532
NS-9	2,113	0	2,286	0	2,465	0	2,686	0	2,910	2,182	3,718	2,788
TOTAL	26,171	17,220	32,215	19,818	38,561	29,433	44,786	36,080	51,062	44,627	68,485	62,482

TABLE 3-5

FORECAST POPULATIONS
SPOKANE VALLEY SERVICE AREA

	1980		1985		1990		1995		2000		2020	
Subunits	Gross	Served	Gross	Served	Gross	Served	Gross	Served	Gross	Served	Gross	Served
SV-1	2,431	1,993	2,774	2,413	3,136	2,885	3,406	3,236	3,677	3,493	5,082	4,828
SV-2	8,742	7,868	9,102	8,374	9,479	9,005	9,754	9,461	10,034	10,034	11,500	11,500
SV-3	32,947	28,071	34,237	29,663	35,604	31,691	36,852	33,288	38,129	34,245	43,830	38,996
SV-4	13,198	9,898	15,510	12,408	17,864	14,291	20,429	17,365	22,818	20,080	30,929	27,836
SV-5	2,440	1,708	2,530	1,898	2,625	1,969	2,714	2,036	2,806	2,104	3,267	2,450
SV-6	1,113	556	1,142	571	1,173	586	1,228	614	1,286	643	1,575	945
SV-7	1,963	0	2,205	0	2,459	0	2,631	0	2,808	0	3,560	0
SV-8	2,523	0	2,805	0	3,102	0	3,421	0	3,745	0	5,190	0
SV-9	1,574	472	1,716	601	1,864	746	2,022	910	2,182	982	2,837	1,418
SV-10	2,373	1,661	2,512	1,809	2,657	1,993	2,877	2,244	3,100	2,480	3,586	3,048
TOTAL	69,304	52,227	74,533	57,737	79,963	63,166	85,334	69,154	90,585	74,061	111,356	91,021

Wastewater Flow

Per capita water use is very high throughout the urban planning area due to the abundance of low cost water and the need for high rates of landscape irrigation during the summer. Water consumption rates for the City are approximately 290 gallons per capita per day (gpcd) on an annual average basis and suburban use ranges to over 500 gpcd, also on an annual average basis. The evaluation of the proportion of water used which could reach septic tanks or sewer systems throughout the urban area relies strongly on the City sewage flow experience since it is the only available municipal wastewater data in the urban area. Analysis of the City experience with recognition of their present infiltration problems, annual flow pattern and commercial-industrial component permits establishment of unit waste flow criteria for the urban area.

For the City, per capita flows, exclusive of infiltration but including the commercial component, are selected to range from 123 gpcd in 1975 to 135 gpcd in year 2020. Criteria for other suburban areas are established with recognition of the probable variation in commercial component ranging from 91 gpcd for areas with negligible commercial to 107 gpcd with significant commerical in 1975. Growth in future use for suburban areas is evaluated at low levels comparable to those forecast for the City.

There are no industrial wastewater flows inside the City which discharge separately from the City sewage collection system. The degree to which the City area is built up and the forecast industrial employment in the City minimize the possibility of future industry with a different character than that already in existence. Therefore, the projected industrial flows inside the City are developed from forecast industrial employment and are assumed to discharge to the City collection system.

In North Spokane and Spokane Valley, where there are no municipal sewerage systems, the industries are currently providing their own separate disposal. The size and character of these large industries suggest that they would continue to provide all or most of their own disposal in the future. Industrial employment forecasts indicate relatively little growth in large industries of the types presently existing and more growth in lighter types of industry with smaller waste flow suitable for inclusion in municipal systems. Therefore, the industrial wastewater forecast for North Spokane and Spokane Valley is developed in two components, one for heavy industry similar to that now in existence and one for light industry. The forecast industrial employment and the forecast industrial wastewater flows for the three primary service areas are shown in Table 3-6.

TABLE 3-6

FORECAST INDUSTRIAL EMPLOYMENT
AND WASTEWATER FLOWS

		Units	1975	1980	1985	1990	1995	2000	2020
SPOKANE VALLEY	Forecast Industrial Employment	persons	6553	6750	7067	7444	7919	8392	9781
	Employment in Primary Ind.	persons	2900	2973	3046	3119	3192	3265	3555
	" " Other "	persons	3653	3777	4021	4325	4727	5127	6226
	Unit flow, primary ind.	gpcd	9600	9600	9700	9800	9900	10,000	10,000
	Total " " "	mgd	27.84	28.54	29.55	30.57	31.60	32.65	35.50
	Process portion @35%	mgd	9.74	9.99	10.34	10.70	11.06	11.43	12.42
	Cooling portion @65%	mgd	18.10	18.55	19.21	19.87	20.54	21.22	23.08
	Unit flow, other ind.	gpcd	212	220	230	240	250	250	250
	Total " " "	mgd	.77	.83	.92	1.04	1.18	1.28	1.56
	Process portion @75%	mgd	.58	.62	.69	.78	.89	.96	1.17
	Cooling portion @25%	mgd	.19	.21	.23	.26	.29	.32	.39
	Total all industrial	mgd	28.61	29.37	30.47	31.61	32.78	33.93	37.06
	Process portion of all	mgd	10.32	10.61	11.03	11.48	11.95	12.39	13.59
	Cooling portion of all	mgd	18.29	18.76	19.44	20.13	20.83	21.54	23.47
CITY OF SPOKANE	Forecast Industrial Employment	persons	17,139	17,789[1]	18,515	19,330	20,299	21,219	23,785
	Unit flow	gpcd	204	220	230	240	250	250	250
	Total flow	mgd	3.50	3.91	4.26	4.64	5.07	5.30	5.95
	Process portion @75%	mgd	2.63	2.93	3.20	3.48	3.80	3.98	4.46
	Cooling portion @25%	mgd	.87	.98	1.06	1.16	1.27	1.32	1.49
NORTH SPOKANE	Forecast Industrial Employment	persons	3072	3256	3406	3584	3799	4023	4700
	Employment in primary type	"	1836	1946	2036	2142	2270	2404	2809
	" " other "	"	1236	1310	1370	1442	1529	1619	1891
	Unit flow, primary	gpcd	1900	1900	1900	1950	1950	2000	2000
	Total flow, primary	mgd	3.488	3.697	3.868	4.177	4.426	4.808	5.618
	Process Portion of primary @10 %	mgd	0.349	0.370	0.387	0.418	0.443	0.481	0.562
	Cooling Portion of primary @90 %	mgd	3.139	3.327	3.481	3.759	3.983	4.327	5.056
	Unit flow, other	gpcd	200	220	230	240	250	250	250
	Total flow, other	mgd	0.247	0.288	0.315	0.346	0.382	0.405	0.473
	Process portion of other @75 %	mgd	0.185	0.216	0.236	0.260	0.287	0.304	0.355
	Cooling portion of other @25 %	mgd	0.062	0.072	0.079	0.086	0.095	0.101	0.118
	Total all	mgd	3.735	3.985	4.183	4.523	4.808	5.213	6.091
	Process portion of all	mgd	0.534	0.586	0.623	0.678	0.730	0.785	0.917
	Cooling portion of all	mgd	3.201	3.399	3.560	3.845	4.078	4.428	5.174

[1] From 1980 on, City employment includes planning units Southwest and Moran Prairie.

Infiltration flows for the City are projected on the assumption that the major defects identified by Bovay (1974a) will be corrected and that the total City infiltration will be reduced to 3.5 mgd. For areas that are presently unsewered, infiltration allowances are developed on a conservative consideration of current leakage specification and the estimated groundwater conditions at sewer depth. Although much of the urban planning area is in well drained soils with the water table below sewer depth, a nominal infiltration allowance is included in all cases.

Infiltration values are evaluated recognizing both the groundwater condition and the length of sewers required which varies inversely with population density. Values range from the equivalent of 10 gpcd in areas of optimum groundwater conditions and high density to 35 gpcd in areas of high groundwater and low density.

Tables 3-7, 3-8 and 3-9 summarize the development of forecast flows for the City, North Spokane and Spokane Valley service areas, combining the municipal-commercial, tributary industrial and infiltration flows to arrive at the total average dry weather flow (ADWF).

TABLE 3-7

POPULATION AND WASTEWATER FLOW FORECAST
CITY OF SPOKANE[1]
SERVICE AREA

		Forecast By Year					
Component	Units	1980	1985	1990	1995	2000	2020
Population							
Gross	Persons	186,278	189,052	191,988	195,068	198,210	212,415
Service	Persons	177,945	180,120	182,506	185,437	189,282	204,315
MUNICIPAL WASTEWATERS							
Average Flow							
Residential-Commercial	mgd	22.472	23.439	24.081	24.612	25.242	27.125
Industrial	mgd	3.972	4.327	4.712	5.147	5.376	6.033
Infiltration[2]	mgd	3.582	3.588	3.593	3.608	3.632	3.697
Total Dry Weather (ADWF)	mgd	30.03	31.354	32.39	33.37	34.25	36.86
Peak Wet Weather Flow (PWWF)[3]	mgd	52.5	53.6	55.4	57.2	58.7	63.4
SEPARATE INDUSTRIAL							
Process	mgd	None	-	-	-	-	-
Cooling	mgd	None	-	-	-	-	-
Total	mgd	None	-	-	-	-	-

[1] Including Moran Prairie and Southwest assuming sewer separation.
[2] Assumes identified infiltration.
[3] Excludes storm sewer flow.

TABLE 3-8

POPULATION AND WASTEWATER FLOW FORECAST
NORTH SPOKANE
SERVICE AREA

Component	Units	Forecast By Year 1980	1985	1990	1995	2000	2020
Population							
Gross	Persons	26,171	32,215	38,561	44,786	51,062	68,485
Service	Persons	17,220	19,818	29,443	36,080	44,627	62,482
MUNICIPAL WASTEWATERS							
Average Flow							
Residential-Commercial	mgd	1.863	2.197	3.218	3.943	4.868	6.744
Industrial[1]	mgd	.280	.305	.331	.361	.388	.440
Infiltration	mgd	.249	.252	.364	.456	.539	.773
Total Dry Weather (ADWF)	mgd	2.39	2.75	3.91	4.76	5.80	7.96
Peak Wet Weather Flow (PWWF)	mgd	6.3	7.1	9.8	11.6	13.9	18.4
SEPARATE INDUSTRIAL							
Process	mgd	.37	.39	.42	.44	.48	.56
Cooling	mgd	3.33	3.48	3.76	3.98	4.33	5.06
Total	mgd	3.70	3.87	4.18	4.42	4.81	5.62

[1]**The industrial totals here do not exactly match those on Table 3-6 due to the process of allocation to subareas and subsequent reassembly.**

TABLE 3-9

POPULATION AND WASTEWATER FLOW FORECAST
SPOKANE VALLEY
SERVICE AREA

Component	Units	Forecast By Year 1980	1985	1990	1995	2000	2020
Population							
Gross	Persons	69,300	74,533	79,963	85,334	90,585	111,356
Service	Persons	52,227	57,737	63,166	69,154	74,061	91,021
MUNICIPAL WASTEWATERS							
Average Flow							
Residential-Commercial	mgd	5.456	6.181	6.857	7.548	8.131	9.933
Industrial	mgd	.808	.883	.970	1.074	1.130	1.306
Infiltration	mgd	.761	.729	.717	.785	.769	.949
Total Dry Weather (ADWF)	mgd	7.03	7.79	8.54	9.41	10.03	12.19
Peak Wet Weather Flow (PWWF)	mgd	16.6	18.1	19.8	21.3	22.7	27.1
SEPARATE INDUSTRIAL							
Process	mgd	9.99	10.34	10.70	11.06	11.43	12.42
Cooling	mgd	18.55	19.21	19.87	20.54	21.22	23.08
Total	mgd	28.54	29.55	30.57	31.60	32.65	35.50

For the computation of peak wet weather flow (PWWF) an inflow allowance is also included. This allowance is evaluated as equal to 25 gpcd plus 150 gallons per acre day (gpad). A peak to average ratio is applied to the municipal-commercial and tributary industrial flow components from a curve relating to ADWF. Ratios range from 2.4 at 2 mgd ADWF to 1.8 at 40 mgd ADWF. Forecast PWWF for each service area is also shown on Tables 3-7, 3-8 and 3-9.

Although the communities occupying the area west of the City are not truly part of the urban area they are near enough to warrant consideration for possible inclusion in an urban plan, particularly if an augmented water supply is provided as proposed in Black and Veatch (1973). For this reason, a wastewater flow forecast is developed for the group of communities herein identified as West Plains including the communities of Airways Heights, Fairchild AFB, Medical Lake and Cheney. Flows from these communities are forecast based on different criteria than selected for the urban area to recognize the scarcity of water and the different soil conditions. The forecast ADWF for year 2000 based on the population forecast shown in Table 3-10 is 2.5 mgd. For augmented water supply conditions per Black and Veatch (1973) the most probable population forecast is approximately 50 percent higher, resulting in a possible ADWF of 3.7 mgd.

TABLE 3-10

SUMMARY, WASTEWATER FLOW FORECAST
URBAN PLANNING AREA
AT YEAR 2000

Service Area	Municipal Flows, mgd		Separate Industrial Flows, mgd		
	ADWF	PWWF	Process	Cooling	Total
City ind. Moran Prairie and Southwest	34.3	58.7	None	None	None
North Spokane	5.8	13.9	.5	4.3	4.8
Spokane Valley	10.0	22.7	11.4	21.2	32.6
Subtotal	50.1	95.3	11.9	25.5	37.4
West Plains[1]	2.5[2] 3.7[3]	6.8 9.0	None	None	None

[1]Defined as including Airway Heights, Fairchild AFB, Medical Lake and Cheney.
[2]Without augmented water supply.
[3]With augmented water supply, from Black and Veatch (1973).

A summary wastewater flow forecast for year 2000 is shown in Table 3-10. This forecast indicates that the total urban area municipal flow, exclusive of West Plains, is 50 mgd ADWF. Separate industrial process flows are forecast at 11.9 mgd located almost entirely in Spokane Valley. Industrial cooling water flows are forcast at 25.5 mgd, again mostly in Spokane Valley.

Wastewater Pollution Load

Per capita pollutant contributions are forecast based on available information from City STP records and from literature sources. Selected criteria for projected 1980 and year 2000 conditions are shown in Table 3-11.

TABLE 3-11

FORECAST PER CAPITA POLLUTANT LOADINGS IN URBAN PLANNING AREA

Pollutant	Loadings - Pounds Per Capita Per Day (ppcd) 1980	2000
BOD	0.19	0.21
Suspended Solids	0.19	0.21
Total N	0.031	0.035
Organic N	0.012	0.014
Ammonia N	0.019	0.021
Total P	0.010	0.012
Ortho P	0.006	0.008

The tributary industrial component is evaluated separately, based on historical experience. The total forecast daily pollutant load for significant parameters as summarized from the residential-commercial and tributary industrial components are shown in Table 3-12. Note that these pollutant loads are in untreated wastewater.

The separate industrial pollutant load forecast is based on the expected concentrations in the treated effluent since this is the only form in which historical data are available. It is assumed the effluent would conform to requirements of current discharge permits. Forecasts for 1980 and year 2000 are summarized in Table 3-13.

TABLE 3-12

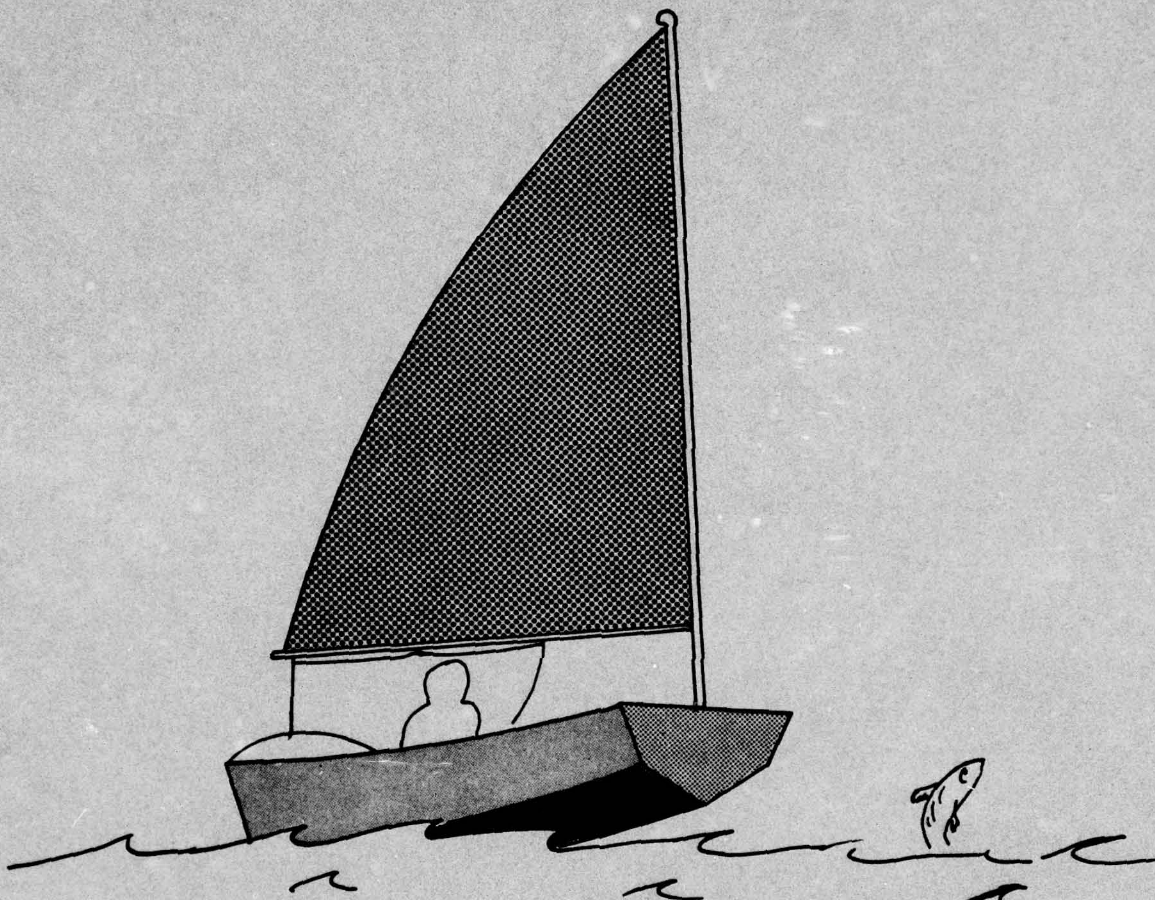
FORECAST POLLUTANT LOADS
RAW MUNICIPAL WASTEWATERS
IN URBAN PLANNING AREA

Component	Units	BOD 1980	BOD 2000	Suspended Solids 1980	Suspended Solids 2000	Total N 1980	Total N 2000	Total P 1980	Total P 2000
CITY									
Residential-Commercial	Pounds/day	33,810	39,749	33,810	39,749	5,516	6,625	1,779	2,271
Industrial	"	11,559	10,092	8,258	6,735	943	1,009	323	337
Subtotal	"	45,369	49,841	42,068	46,484	6,459	7,634	2,102	2,608
Concentration in ADWF	mg/l	181	175	168	163	25.8	26.8	8.4	9.1
NORTH SPOKANE									
Residential-Commercial	Pounds/day	3,272	9,372	3,272	9,372	534	1,562	172	536
Industrial	"	525	727	350	485	52	·73	17	24
Subtotal	"	3,797	10,099	3,622	9,857	586	1,635	189	560
Concentration in ADWF	mg/l	191	209	182	204	29.4	33.9	9.5	11.6
SPOKANE VALLEY									
Residential-Commercial	Pounds/day	9,923	15,553	9,923	15,533	1,619	2,592	522	889
Industrial	"	1,514	2,119	1,010	1,413	151	212	50	71
Subtotal	"	11,437	17,672	10,933	16,946	1,770	2,804	572	960
Concentration in ADWF	mg/l	195	212	187	203	30.2	33.6	9.8	11.5
TOTAL URBAN AREA	Pounds/day	60,603	77,612	56,623	73,287	8,815	12,073	2,863	4,128

TABLE 3-13

FORECAST POLLUTANT LOAD
IN TREATED EFFLUENTS OF
SEPARATE INDUSTRIAL DISCHARGES

	Loadings - Pounds Per Day							
	BOD		Suspended Solids		Total N		Total P	
	1980	2000	1980	2000	1980	2000	1980	2000
North Spokane	27	54	62	81	157	160	13	14
Spokane Valley	1360	1556	975	1116	90	103	67	77
TOTALS	1387	1610	1037	1197	247	263	80	91



SECTION 4

WATER QUALITY GOALS AND DISPOSAL CRITERIA

4. Water Quality Goals and Disposal Criteria

General

The primary statutory definitions of water quality goals and criteria derive from Public Law 92-500. Administrative interpretation of this law has been under way since its passage and continues as of the date of this report. Basic policy is set in Public Law 92-500 but enforcement and certain generally additive options in criteria establishment are delegated to the States.

It is assumed that the earliest possible on-line implementation of any major plan for wastewater management resulting from this study will be 1980. Therefore, any facility put into service at that date must anticipate the 1983 milestone requirements of Public Law 92-500.

The 1983 milestone requirements of Public Law 92-500 are the attainment of "best practicable waste treatment technology" (BPWTT) by publicly owned treatment facilities. Specification of BPWTT as a disposal requirment is control through effluent standards rather than on the basis of the assimilative capacity of the receiving waters. The law, however, also provides that certain receiving waters may be classified by the respective states as water quality determinative if degradation would result from discharges meeting effluent standards. In such cases, Public Law 92-500 provides that more stringent effluent requirements may be determined by the State. The three major streams of the study area, Spokane River, Little Spokane River and Hangman Creek, are classified by the State as water quality determinative.

Administrative guidelines[1/] have been issued by the U.S. Environmental Protection Agency (EPA) to define BPWTT. Two general approaches are permitted, one leading to surface water disposal and one leading to land application.

[1/] Alternative waste management techniques for best practicable waste treatment. Draft proposed for public comment, March 1974. U.S. Environmental Protection Agency.

BPWTT Applied to Surface Disposal

Except for allowing the States to determine the need for nitrification or nutrient removal on a case-by-case basis, the proposed guidelines for BPWTT are essentially unchanged from the 1977 milestone requirements for secondary treatment. Acceptable secondary treatment techniques for disposal to surface waters include:

1. Activated sludge process.

2. Trickling filter (or rotating disc or other processes in which the active organisms are fixed rather than free floating).

3. Lagoons with multiple cells and intermittant discharge capabilities at loadings of 20 pounds of BOD_5 per acre and 6 month detention. Continuous discharge lagoons will not meet BPWTT. Equivalent BPWTT performance can be achieved with lesser storage and higher loads by the addition of primary sedimentation pretreatment and mechanical aeration.

4. Physical-chemical processes including at least chemical precipitation followed by filtration.

5. Land application.

In terms of performance, the required effluent quality is required to be as shown in Table 4-1.

As indicated above, the State has designated the Spokane River, Little Spokane River and Hangman Creek as water quality determinative. It is necessary to examine the specific requirements for each to determine the difference in disposal requirements from those based on the above effluent standards alone.

The classifications and specific deficiencies for each designated water quality determinative segment are as follows:

The Spokane River is specifically cited as being Class A water from mouth to Idaho Boundary and has a special proviso with regard to water temperature limits, raising the maximum to 68°F rather than the typical 65°F. Long Lake, which is included in this reach of the Spokane River, is presumed to be Lake Class since it has a mean detention in excess of 15 days. All other streams are designated Class A. A definition of Class A and Lake Class waters is shown in Table 4-2.

TABLE 4-1

GUIDELINES FOR SECONDARY TREATMENT[1]

Parameter	Sampling Period	Maximum Mean[2] Value, Effluent Quality
1. The minimum level of effluent quality to be classified as secondary treatment is defined in terms of the following values for parameters in plant effluent:		
BOD (5 day)	30 consecutive days	30 milligrams per liter or 15 percent of the mean influent BOD, whichever is smaller
BOD (5 day)	7 consecutive days	45 milligrams per liter
Suspended Solids	30 consecutive days	30 milligrams per liter or 15 percent of the mean influent SS, whichever is smaller
Solids	7 consecutive days	45 milligrams per liter
Fecal Coliform	30 consecutive days	200 per 100 milliliters
Fecal Coliform	7 consecutive days	400 per 100 milliliters
pH	Continuously	Within the limits 6.0 to 9.0

2. Special consideration is given to treatment plants serving areas with combined sewer and certain industrial waste categories.

   a. Treatment works which receive flows from combined sewers may receive special consideration in the standards to be met while handling wet weather flow on a case-by-case review basis.

   b. Certain categories of industrial wastes which discharge directly to navigable waters or through a municipal treatment plant to navigable waters are subject to possible effluent quality adjustment for BOD and SS. Where the flow is treated in a municipal plant, it must exceed 10 percent of the total flow to be eligible for consideration.

[1]Guidelines for the requirements of secondary treatment become effective 17 August 1973. Refer to Federal Register Vol. 30, No. 159, Friday 17 August 1973.

[2]Arithmetic mean for BOD and SS; Geometric mean for Fecal Coliform.

TABLE 4-2

DEFINITION OF STATE WATER QUALITY CLASSES[1]

Class	Requirements
Class AA (Extra-ordinary)	a. General characteristic: Water quality of this class shall markedly and uniformly exceed the requirements for all or substantially all uses.
	b. Characteristic uses: Characteristic uses shall include, but are not limited to the following. i) Water supply (domestic, industrial, agricultural) ii) Wildlife habitat, stock watering iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing and boating) iv) General marine recreation and navigation v) Fish and shellfish reproduction, rearing and harvest.
	c. Water quality criteria i) Total coliform organisms shall not exceed median values of 50 (fresh water) or 70 (marine water) with less than 10% of samples exceeding 230 when associated with any fecal source. ii) Dissolved oxygen shall exceed 9.3 mg/l (fresh water) or 7.0 mg/l (marine water). iii) Total dissolved gas concentration shall not exceed 110% of saturation at any point of sample collection. iv) Temperature of water shall not exceed 60°F. (fresh water) or 55°F. (marine water) due in part to measurable (0.5°F.) increases resulting from human activities; nor shall such temperature increases, at any time, exceed $t = 75/(T-22)$ (fresh water) or $t = 24/(T-39)$ (marine water); for purposes hereof "t" represents the permissive increase and "T" represents the water temperature due to all causes combined. v) pH shall be within the range of 6.5 to 8.5 (fresh water) or 7.0 to 8.5 (marine water) with an induced variation of less than 0.1 units. vi) Turbidity shall not exceed 5 JTU over natural conditions. vii) Toxic, radioactive or deleterious material concentrations shall be less than those which may affect public health, the natural aquatic environment, or the desirability of the water for any usage. viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.
Class A (Excellent)	a. General characteristic: Water quality of this class shall meet or exceed the requirements for all or substantially all uses.
	b. Characteristic uses: Characteristic uses shall include, but are not limited to, the following. i) Water supply (domestic, industrial, agricultural) ii) Wildlife habitat, stock watering iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing and boating) iv) Commerce and navigation v) Fish and shellfish reproduction, rearing and harvest
	c. Water quality criteria i) Total coliform organisms shall not exceed median value of 240 (fresh water) with less than 20% of samples exceeding 1000 when associated with any fecal sources or 70 (marine water) with less than 10% of samples exceeding 230 when associated with any fecal sources. ii) Dissolved oxygen shall exceed 8.0 mg/l (fresh water) or 6.0 mg/l (marine water). iii) Total dissolved gas concentration shall not exceed 110% of saturation at any point of sample collection. iv) Temperature of water shall not exceed 65° F. (fresh water) or 61° F. (marine water) due in part to measurable (0.5° F.) increases resulting from human activities; nor shall such temperature increases, at any time

TABLE 4-2 (Cont.)

DEFINITION OF STATE WATER QUALITY CLASSES[1]

Class	Requirements
	exceed t = 90/(T-19) (fresh water) or t = 40/(T-35) (marine water); for purposes hereof "t" represents the permissive increase and "T" represents the water temperature due to all causes combined.
	v) pH shall be within the range of 6.5 to 8.5 (fresh water) or 7.0 to 8.5 (marine water) with an induced variation of less than 0.25 units.
	vi) Turbidity shall not exceed 5 JTU over natural conditions.
	vii) Toxic, radioactive or deleterious material concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.
	viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.
Lake Class	a. General characteristic: Water quality of this class shall meet or exceed the requirements for all or substantially all uses.
	b. Characteristic uses: Characteristic uses for waters of this class shall include, but are not limited to, the following.
	i) Water supply (domestic, industrial, agricultural)
	ii) Wildlife habitat, stock watering
	iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing and boating)
	iv) Fish and shellfish reproduction, rearing and harvest
	c. Water quality criteria
	i) Total coliform organisms shall not exceed median values of 240 with less than 20% of samples exceeding 1000 when associated with any fecal source.
	ii) Dissolved oxygen shall have no measurable decrease from natural conditions.
	iii) Total dissolved gas concentration shall not exceed 110% of saturation at any point of sample collection.
	iv) Temperature - no measurable change from natural conditions.
	v) pH - no measurable change from natural conditions.
	vi) Turbidity shall not exceed 5 JTU over natural conditions.
	vii) Toxic, radioactive or deleterious material concentrations shall be less than those which may affect public health, the natural aquatic environment or the desirability of the water for any usage.
	viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

[1]Source: Washington Administrative Code (WAC) 173-201.

The NPDES discharge permit for the City STP calls for total phosphorus removal of 85 percent or better on a year around basis. This phosphorus removal criteria would apply to all other significant discharges to the Spokane River and its tributaries above Long Lake.

In addition to the above cited requirements for surface water disposal in the study area, DOE has policy considerations for dilution. In general, a dilution ratio of 1:20 or greater must be provided at 7-day 10-year low flow conditions; if not, treatment level must be "advanced." Advanced treatment is defined as that which will provide the removals indicated in Table 4-3.

TABLE 4-3

DEFINITION OF ADVANCED TREATMENT[1]

Item	Amount
BOD	10 mg/l, or 95% removal, whichever results in a better quality effluent
Suspended Solids	10 mg/l, or 95% removal, whichever results in a better quality effluent
Phosphorus	0.5 mg/l, or 95% removal, whichever results in a better quality effluent
Ammonia	3 mg/l
Total coliform organisms	Shall not exceed median values of 50 organisms per 100 ml with less than 10% of the samples exceeding 230 organisms per 100 ml

[1]Effluent requirements to meet the definition of advanced treatment as given in Department of Ecology Dilution Zone Guidelines.

The DOE has not taken a position on the need for nitrogen removal or nitrification except in the case of the advanced treatment requirement for dilutions of 1:20 or less.

Considering the foregoing Federal and State requirements, surface water discharges, where greater than 1:20 dilution exists, require secondary treatment plus 85 percent phosphorus removal. Considering criteria being established elsewhere for ammonia toxicity and the low flow dilution limitations in the Spokane River, a potential need for ammonia removal or denitrification is seen under certain conditions.

This study develops suggested ammonia toxicity limitation criteria as follows, expressed in terms of concentrations in the receiving waters after mixing and at a pH not to exceed 8.0:

1. Not to exceed 0.2 mg/l ammonia as N at mean monthly flow.

2. Not to exceed 0.5 mg/l ammonia as N at minimum mean monthly flow of record.

3. Not to exceed 0.6 mg/l ammonia as N for 7-day 10-year low flow.

The stated DOE requirement for 85 percent phosphorus removal is on a year-round basis. There is no official recognition of a possible alternative which would require phosphorus removal only at such times of the year that prove to be necessary to limit summer algae growth. This study considers the possibility of seasonal removals as an alternative through simulation modeling and in cost-effective analysis.

Other Requirements for Fish Habitat

It should be recognized that the proposed upgrade of the City STP to secondary treatment may expose problems from contaminants not presently a matter of concern. The reach of the Spokane River below the City STP at present is devoid of a fish population. After the upgrade, conditions should be so improved that, considering gross pollution parameters, a fishery should be feasible. Removal of the gross pollution, however, may then reveal difficulty with other contaminants under certain dilution conditions. One of the most obvious is ammonia toxicity which is addressed above. Others which should be monitored for their effect when a fish population is being re-established are chlorine and chlorine compounds from disinfection, heavy metals from undetected industrial sources, detergent residuals and organic compounds such as pesticides.

Low Flows of Principal Streams

Statistical analysis of streamflow data yields the following results for the 7-day low flow with 10-year return frequency:

Stream	Analysis Based on Records of USGS Gage Number	7-day 10-year Low flow, cfs
Spokane River near Port Falls	4190	195
Spokane River at Spokane	4225	860
Hangman Creek at Spokane	4240	3.4
Little Spokane River at Dartford	4310	92

These flows provide a basis for evaluation of critical dilution ratios and pollutant concentrations. Note that the Spokane River at Spokane contains the effect of the major groundwater inflow to the river between the Idaho boundary and the confluence of Hangman Creek. On the other hand, the Little Spokane River record at Dartford does not include the major groundwater inflow to that stream, amounting to an estimated 200 cfs which enter below Dartford.

BTWTT for Land Application of Wastewater

A distinction is made here between wastewaters and the solids or solids slurry (sludge) from wastewaters. Criteria specific to the latter are discussed in a following paragraph.

The EPA guidelines specify three acceptable approaches to land application: (1) irrigation, (2) overland flow and (3) infiltration-percolation. For irrigation, the ultimate disposal may be either to groundwater and evapotranspiration or to surface water. For overland flow the ultimate disposal is usually to surface water. For infiltration-percolation, the ultimate disposal may be either directly to water or via underdrains to surface water. In no case is the quality specified for the wastewater as applied to the land surface either in terms of pollutant concentration or as the output of an acceptable process. Controls are specified in terms of the quality reaching the ultimate disposal waters. Subsequent guidelines for wastewater solids application to land consider limitations on application determined in terms of the ability of vegetative cover to utilize nutrients. Presumably, revised guidelines for wastewater will include a similar approach.

The State DOE has no official guidelines for land application of wastewater to supplement the Federal guidelines. A policy draft was prepared in 1971 as a joint effort of DOE and the State Department of Social and Health Services (DSHS) but was never officially adopted. This early draft is considered by current staff to be more restrictive than the present concensus.

The acceptability of land application techniques under EPA guidelines where all or part of the renovated wastewater reaches groundwater is defined in terms of its effect on quality. The effects are unqualified with regard to the degree of stratification or mixing between the leachate and the native groundwater. The standards of quality referred to are drinking water standards. Until a specific wastewater is being dealt with and the content of such contaminants as pesticides is known, the most important common parameter of concern is total nitrogen with a maximum of 10 mg/l.

Where the land application technique results in discharge to surface waters. such as underdrained irrigation or ditch collected overland flow, the effluent is required to be as specified for surface water discharge from any other treatment facility.

Acceptable irrigation techniques include spray, ridge and furrow and flooding. Acceptable plant cover includes annual and perennial crops, pasture, landscape, tree farm and forest. The only criteria for acceptability other than the above described effects on groundwater and surface water quality are the functional adequacy of the combination of application rate, soil type, topography, depth to groundwater and cover material. There are no stated limitations on the character of the wastewater as applied.

The proposed EPA guidelines indicate that the expected treatment to be achieved by soil as the applied irrigation water passes through the active layer will be as follows, based on the applied waters having had prior secondary treatment:

Parameter	Expected Incremental Removal
BOD and SS	90 - 99%
Nitrogen	85 - 90%
Phosphorus	80 - 99%

Short of making a pilot field study of a specific combination of crop, soil, climate and application rate, it must be assumed that secondary treated municipal wastewater applied to the land by irrigation will achieve the goals of BPWTT with respect to protection of groundwater and surface water if there is adequate active soil depth and the application rate is not excessive.

An hydraulic application rate of 4 inches per week is given for definition purposes to define the upper limit of irrigation as distinguished from infiltration-percolation. The actual acceptable application rate must be determined for each specific combination of applied wastewater, soil, crop and climate. Note that although a large proportion of applied water may be disposed by evapotranspiration, either excess application or rainwater must be allowed to flush unused salts to groundwater or underdrains to prevent salt buildup which would eventually poison the land.

Application by irrigation on frozen ground is not specifically prohibited by the proposed guidelines. The precautionary statement is made that there is conflicting data. For the purpose of this study, it is assumed that irrigation on frozen ground is not an acceptable form of BPWTT disposal.

Overland flow relies upon treatment achieved at the ground surface rather than within the soil as is the case for irrigation. Percolation to groundwater is usually small or negligible since relatively impermeable soils are required for acceptable practice. Due to the lack of suitable land in the study area (impermeable land with relatively low gradient of two to six percent), this alternative is not addressed in the same depth as irrigation and infiltration-percolation.

The application rates for overland flow land treatment process are not related to evapotranspiration or percolation but rather to contact

time as the flow, in excess of what can be utilized by the cover crop or absorbed by the soil, transverses the surface. The treatment process is more analogous to a trickling filter in that biota on the cover crop and ground surface act similarly to the biota on the media of the filter. A typical application rate is 4 inches per week applied in cycles of 6 to 8 hours of spraying followed by 6 to 18 hours of drying. The expected removals are as follows assuming secondary treatment prior to application:

Parameter	Expected Incremental Removal
BOD and SS	95 - 99%
Nitrogen	70 - 90%
Phosphorus	50 - 60%

The cover crop for overland flow treatment is necessarily permanent, although it may require periodic cutting, and is not usually a potentially usable crop. The proposed guidelines classify overland flow as a land application technique. Functionally, it is a polishing treatment for surface water disposal.

A suitable site providing an acceptable combination of soil characteristics and depth to groundwater are critical to infiltration-percolation treatment which will satisfy BPWTT. Soils that are too coarse and allow the applied wastewater to pass through the upper layer too quickly to experience the necessary biological and chemical action are not acceptable. Depth to groundwater should be at least 15 feet to insure treatment before the wastewater enters the saturated zone. Soils with inadequate permeability will not support hydraulic loading rates that make the method economically competitive with other land application methods.

As for the other land application methods, the proposed guidelines do not specify any limitation on the quality of the wastewater as applied. The interrelationship between quality applied and maintenance of hydraulic loading capability is pointed out. It is noted that most successful systems for municipal wastewater have applied waters of secondary quality.

Expected incremental removals by infiltration-percolation from applied waste of secondary effluent quality are over 90 percent for BOD, SS and coliforms and 70 to 90 percent for phosphorus. Nitrogen removal is noted as being highly variable, 0 to 80 percent, depending upon specific conditions and mode of operation. The guidelines do not directly address the possible need for nitrogen removal as a pretreatment requirement. Infiltration-percolation is considered to be operable on a year-round basis.

Deepwell injection of wastewater is not considered a treatment alternative under BPWTT, as it provides no substantial renovation to the groundwater, according to the proposed guidelines. The guidelines indicate that deepwell injection may be considered as an alternative

disposal site provided the pretreatment meets the groundwater quality criteria.

Future Disposal Requirements

Corps of Engineers planning policy[1/] requires that the Federal financial interest be protected in the formulation and evaluation of planning alternatives by consideration of the possible consequences of a need to meet more stringent future disposal requirements. Future disposal requirements are defined as those beyond the specified 1983 milestone requirements which could evolve from the stated 1985 goal in Law 92-500 for "no discharge of pollutants." To protect the Federal financial interest, the stated Corps policy is to consider through alternatives two possible planning pathways, one to meet 1983 requirements in the most cost-effective manner without consideration of possible future upgrading and the other to meet 1983 requirement in the most cost-effective manner assuming that 1985 goals will become a requirement and that upgrading of facilities is mandatory.

Since the "1985 goal" is stated in nonspecific terms, it is necessary to develop quantitative criteria by interpretation in order to carry out the Corps planning policy. In a manner similar to that used by EPA to define BPWTT, an interpretation of 1985 goals is made for this study in terms of acceptable alternative treatment processes rather than in terms of numerical quality criteria. The summary results are as follows:

1. For disposal to surface waters, secondary treatment with nutrient removal followed by the equivalent of carbon absorption and sand (or mixed media) filtration, reoxygenation and disinfection with ozone (to avoid the toxicity problems associated with chlorine disinfection).

2. For land treatment application:

    a. Irrigation with secondary effluent monitored to prevent nitrogen application at rates in excess of plant uptake.

    b. Overland flow of secondary effluent at monitored rates to prevent nutrient carryover, with the collected overland flow effluent given the equivalent of sand filtration, reoxygenation and disinfection before release to surface waters.

    c. Infiltration-percolation of secondary treated effluent with nitrogen removal.

[1/] Refer to office of Chief of Engineers publication, "Urban Studies Program," EC 1105-2-35 dated 7 July 1975.

Implicit in any future requirements, as well as those for 1983, is the removal of toxicants and other prohibited substances. Appendix G, Planning Criteria (section 603.1) provides details on critical levels of constituents established for this study.

Wastewater Solids Disposal

Acceptable disposal of wastewater solids can be achieved in four general ways:

1. Sanitary landfill
2. Reduction to an inert ash
3. Conversion to a marketable product
4. Land application

Methods 2 and 3 are not subject to disposal criteria in the sense that 1 and 4 are. Criteria for disposal methods 1 and 4 are provided in proposed EPA guidelines[1/]. Method 1 is also covered in State guidelines[2/] for solid waste disposal.

The salient requirements for sanitary landfill disposal are as follows:

1. The sludge shall be previously stabilized.

2. The sludge shall contain no free moisture.

3. The groundwater shall be protected from leachate.

4. The sludge materials shall be covered daily and the final cover shall be not less than 2 feet thick.

5. The landfill operation shall be operated in the manner defined for sanitary landfill by State law.

The requirements for land application are as follows:

1. The sludge shall be previously stabilized by the equivalent of anaerobic digestion.

2. Where public access is not positively controlled, pathogen reduction beyond that normally achieved by stabilization shall be provided equal to long term storage (60 days at 20°C or 120 days at 4°C).

1/ "Acceptable Methods for the Utilization or Disposal of Sludges", U.S. Environmental Protection Agency, November 1974.

2/ WAC 173-301.

3. Application rates are to be limited.

   a. By crop capability to utilize nitrogen.

   b. By solid cation exchange capacity (CEC) to protect land resource from heavy metal poisoning.

4. Not to be used on crops eaten raw by humans.

5. Cooked or processed foods or crops used for forage should be negative for pathogens.

6. The entire operation to be checked by an ongoing monitoring system.

Urban Runoff Control

The proposed EPA guidelines state:

> Demonstration technology to control storm sewer discharge does not exist. Efforts are being made to quantify the problem and identify the effect on receiving waters.

This is interpreted to mean that, as of March 1974, BPWTT has not been established for treatment of urban runoff but that there will be standards developed before the target date of 1983. Therefore, there are no statutory or administrative guidelines against which to evaluate the impact of urban runoff in this study. In lieu of such guidance, this study relies on comparison with the impact of the municipal wastewaters which are subject to guideline control.

Combined Sewer Control

Although no guidelines are proposed for BPWTT with respect to urban runoff as a separate source of pollution, there are guidelines for control of pollution resulting from combined sewers. These guidelines do not take the form of specific numerical parameters to be met, but rather the form of indicating alternative efforts which should be explored to arrive at a cost-effective method to reasonably minimize pollution from this source. Guidelines do not take the form of absolute elimination of overflows or limiting overflows to a percent of time or total annual pollution load.

The following alternatives are suggested for exploration, with emphasis on the possibility of best cost-effectiveness being found in combination of techniques:

1. Sewer separation.

2. Periodic dry weather flushing to prevent build-up of pollutants.

3. Flow routing to maximize capacity of available sewers and treatment.

4. Storage for subsequent treatment.

5. Increased treatment hydraulic capacity with some sacrifice of removals at wet weather flow.

6. Direct treatment of overflows.

7. Disinfection of overflows.

The alternative methods suggested for direct treatment of overflows are mostly in the experimental or pilot plant stage of development. Acceptable removals or degrees of reliability are not stated.

SECTION 5

WASTEWATER MANAGEMENT NEEDS

5. Wastewater Management Needs

City of Spokane, Municipal

The City has a number of wastewater problems, some of which are being met by concurrent implementation or planning, including the following:

1. Violation of water quality standards through operation of a primary STP which was deficient in removal of BOD, bacteria and phosphorus.

2. Violation of water quality standards through combined sewage overflows both at the treatment plant and throughout the interceptor system.

3. Excessive infiltration in certain areas of the collection system.

4. Local street and basement flooding at various locations throughout the City due to a variety of causes including combined sewers, roots and restricted sewers and structurally failed sewers.

5. An unknown pollutional impact caused by the urban runoff component of the combined sewage flow.

The violations due to treatment plant inadequacies are effectively met by the concurrent construction of an enlarged and upgraded facility. This facility when completed will provide a capacity of 40 mgd with secondary treatment meeting BPWTT and 85 percent phosphorus removal. The solids handling part of the plant will provide anaerobic digestion and vacuum filtration to produce a product suitable for disposal to sanitary landfill.

Violations due to combined sewer overflows at the treatment plant are being dealt with in two ways. First, the enlarged and upgraded treatment plant contains hydraulic capacity and implant storage to carry large storm flows through all or a part of the treatment process to provide a minimum of primary treatment and disinfection and avoid any untreated bypassing. Second, the total storm flow component reaching the plant will be reduced by the proposed program of collection system improvements.

The pollutional impact of combined sewer overflows along the interceptor system is the subject of a plan of study[1] and implementation proposed by the City to be carried out over a period extending to 1986. The estimated planning and construction costs of approximately $46,000,000 make the implementation by the scheduled date highly problematical. The analysis and planning for this work is estimated to cost approximately $250,000. After completion of the treatment plant improvements are an accomplished fact, this unmet need for correction of system overflows will be the most serious threat to Spokane River quality. Although the mass emissions may be relatively small from this source, the fact that the overflows are raw sewage, with all that such implies in the form of aesthetic degradation and bacterial pollution, will truly prevent upgrading the Spokane River to Class A status until completion of the corrections.

The problem of local street and basement flooding with combined sewer wastewaters will be addressed in part by some of the actions taken to solve the combined sewer overflow problem under the above described City plan of study. Many problems of a highly local nature will not be addressed and will remain for correction under other City programs. Wastewater problems of this character are identified in this study but are not the subject of analysis for correction.

The infiltration problems of the City sewage collection system have been the subject of a report[2] by the City's consulting engineers. This report was prepared as prerequisite to grant funding for the treatment plant improvements under Public Law 92-500. Identified sources of infiltration that are subject to cost-effective corrections presumably will be carried out in conformance with Public Law 92-500.

One of the alternative methods to be analyzed in the City plan of study for correction of combined sewer overflow problems is the separation of storm and sanitary sewage. Where this is accomplished, there will be direct discharge of untreated urban runoff to the Spokane River. There will then be an unmet need to evaluate the potential impact of these urban runoff wastewaters to determine their impact on water quality.

In summary, City wastewater needs are currently being met by implementation or planning activity in all areas except for evaluation of impact of separated urban runoff.

1/ Refer to "Plan of Study, Facilities Planning for City of Spokane Sewer Upgrading and Over Flow Correction, September 1974."

2/ Bovay (1974a).

North Spokane, Municipal

The North Spokane area includes lands within the city limits and unincorporated county. The feature that distinguishes the area is that it is not topographically tributary by gravity to the sewered area of the City. For this reason, development in City areas has not been sewered to the City-wide system. Development in unincorporated areas has the same topographic problem plus the institutional one of being outside the City. Practically all of the City area development is served by small collection systems leading to some interim form of treatment facility, either non-overflow lagoons or package plants. The operation of the lagoons has been unsatisfactory and space for their enlargement would conflict with other beneficial land use. Unincorporated areas are predominantly served by on-site disposal (septic tank and drainfield systems) but there are two significant collection systems leading to lagoons. The on-site facilities are subject to a large number of failures due to marginal soil conditions. Significantly, the North Spokane area is forecast to have the most rapid growth in the study area. The areas served by on-site disposal facilities in North Spokane are shown in Figure 5-1.

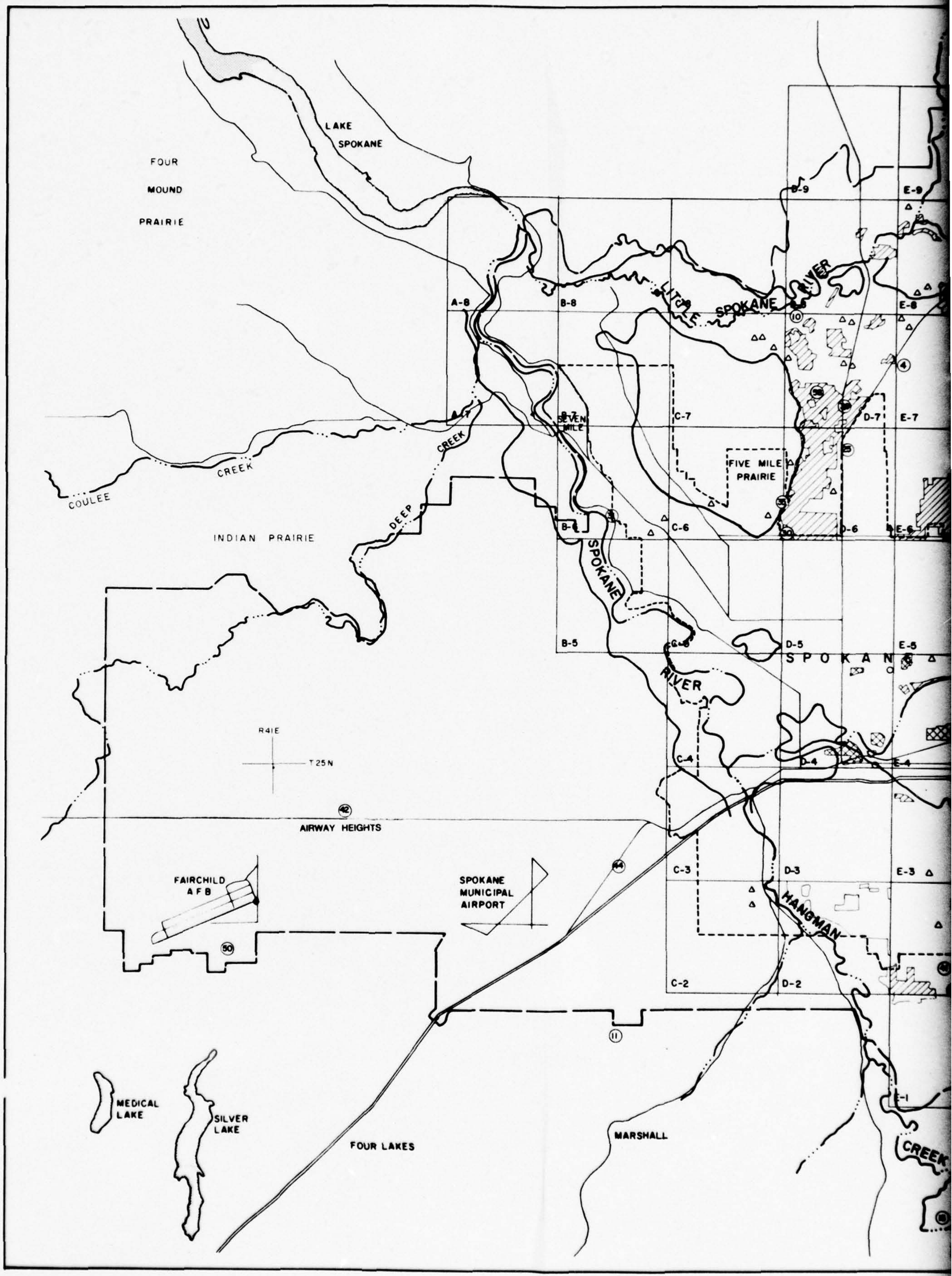
There appears to be general agreement in public opinion that the North Spokane area must give up its current sewage disposal practice in favor of a community collection system and centralized treatment and disposal. Therefore, there is an unmet need for relief of these unsatisfactory wastewater management practices, either as a separate entity or as part of a regional system.

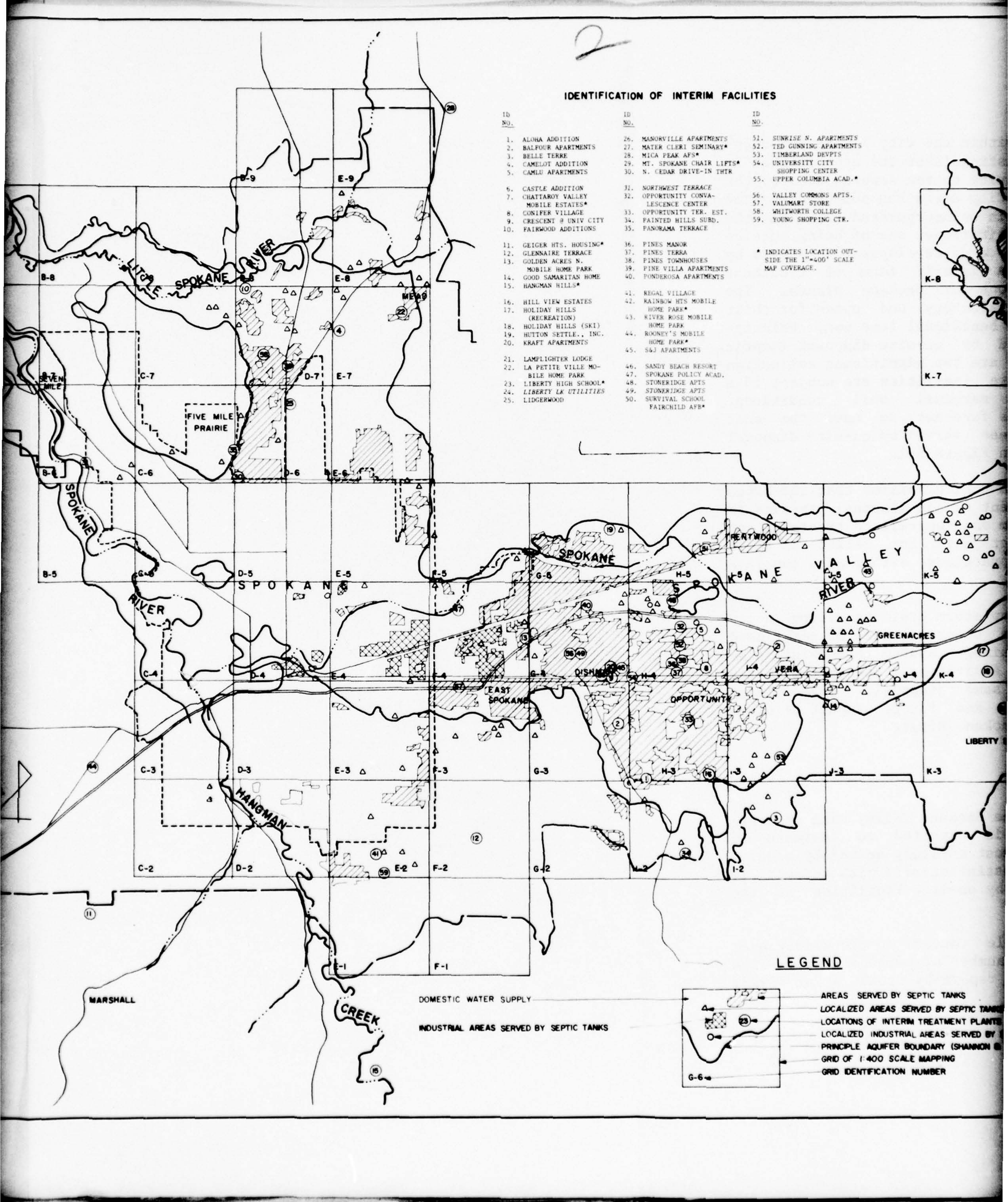
There is not a fully developed urban storm drainage system in the North Spokane area. Flooding problems occur creating an unmet need which is discussed elsewhere. The drainage system that exists discharges to the Little Spokane River. Additions to the system to relieve flooding would probably have the same disposal. There is an unmet need for evaluation of the present and future impact of urban drainage on the quality of the Little Spokane River.

Spokane Valley, Municipal

The largest existing suburban area is the Spokane Valley with an estimated 60,000 persons. The population is expected to increase to 90,000 by year 2000. This area is almost entirely served by on-site disposal which, in general, operates satisfactorily with respect to surface conditions. The areas served by on-site facilities in the Spokane Valley are shown in Figure 5-1.

There has been concern for the possible threat to the widely used Spokane Valley aquifer by the growing number of persons with on-site disposal located over the aquifer. The report by Crosby et al (1973)


LAKE
SPOKANE
FOUR
MOUND
PRAIRIE
LITTLE SPOKANE RIVER
SEVEN MILE
FIVE MILE
PRAIRIE
COULEE
CREEK
DEEP
CREEK
INDIAN PRAIRIE
SPOKANE
SPOKANE
RIVER
R41E
T25N
AIRWAY HEIGHTS
FAIRCHILD
AFB
SPOKANE
MUNICIPAL
AIRPORT
HANGMAN
MEDICAL
LAKE
SILVER
LAKE
FOUR LAKES
MARSHALL
CREEK
A-8
A-7
B-9
B-8
B-7
B-6
B-5
C-7
C-6
C-5
C-4
C-3
C-2
D-7
D-6
D-5
D-4
D-3
D-2
E-9
E-8
E-7
E-6
E-5
E-4
E-3
E-1


2
IDENTIFICATION OF INTERIM FACILITIES
ID NO.
1. ALOHA ADDITION
2. BALFOUR APARTMENTS
3. BELLE TERRE
4. CAMELOT ADDITION
5. CAMLU APARTMENTS
6. CASTLE ADDITION
7. CHATTAROY VALLEY MOBILE ESTATES*
8. CONIFER VILLAGE
9. CRESCENT @ UNIV CITY
10. FAIRWOOD ADDITIONS
11. GEIGER HTS. HOUSING*
12. GLENNAIRE TERRACE
13. GOLDEN ACRES N. MOBILE HOME PARK
14. GOOD SAMARITAN HOME
15. HANGMAN HILLS*
16. HILL VIEW ESTATES
17. HOLIDAY HILLS (RECREATION)
18. HOLIDAY HILLS (SKI)
19. HUTTON SETTLE., INC.
20. KRAFT APARTMENTS
21. LAMPLIGHTER LODGE
22. LA PETITE VILLE MOBILE HOME PARK
23. LIBERTY HIGH SCHOOL*
24. LIBERTY LK UTILITIES
25. LIDGERWOOD
26. MANORVILLE APARTMENTS
27. MATER CLERI SEMINARY*
28. MICA PEAK AFS*
29. MT. SPOKANE CHAIR LIFTS*
30. N. CEDAR DRIVE-IN THTR
31. NORTHWEST TERRACE
32. OPPORTUNITY CONVALESCENCE CENTER
33. OPPORTUNITY TER. EST.
34. PAINTED HILLS SUBD.
35. PANORAMA TERRACE
36. PINES MANOR
37. PINES TERRA
38. PINES TOWNHOUSES
39. PINE VILLA APARTMENTS
40. PONDEROSA APARTMENTS
41. REGAL VILLAGE
42. RAINBOW HTS MOBILE HOME PARK*
43. RIVER ROSE MOBILE HOME PARK
44. ROONEY'S MOBILE HOME PARK*
45. S&J APARTMENTS
46. SANDY BEACH RESORT
47. SPOKANE POLICY ACAD.
48. STONERIDGE APTS
49. STONERIDGE APTS
50. SURVIVAL SCHOOL FAIRCHILD AFB*
51. SUNRISE N. APARTMENTS
52. TED GUNNING APARTMENTS
53. TIMBERLAND DEVPTS
54. UNIVERSITY CITY SHOPPING CENTER
55. UPPER COLUMBIA ACAD.*
56. VALLEY COMMONS APTS.
57. VALUMART STORE
58. WHITWORTH COLLEGE
59. YOUNG SHOPPING CTR.
* INDICATES LOCATION OUTSIDE THE 1"=400' SCALE MAP COVERAGE.
LITTLE SPOKANE RIVER
SPOKANE RIVER
SPOKANE
SPOKANE VALLEY
FIVE MILE PRAIRIE
SEVEN MILE
MEAD
TRENTWOOD
GREENACRES
DISHMAN
EAST SPOKANE
OPPORTUNITY
VERA
LIBERTY
HANGMAN CREEK
MARSHALL
LEGEND
DOMESTIC WATER SUPPLY
INDUSTRIAL AREAS SERVED BY SEPTIC TANKS
AREAS SERVED BY SEPTIC TANKS
LOCALIZED AREAS SERVED BY SEPTIC TANKS
LOCATIONS OF INTERIM TREATMENT PLANTS
LOCALIZED INDUSTRIAL AREAS SERVED BY
PRINCIPLE AQUIFER BOUNDARY (SHANNON
GRID OF 1:400 SCALE MAPPING
GRID IDENTIFICATION NUMBER

2

3

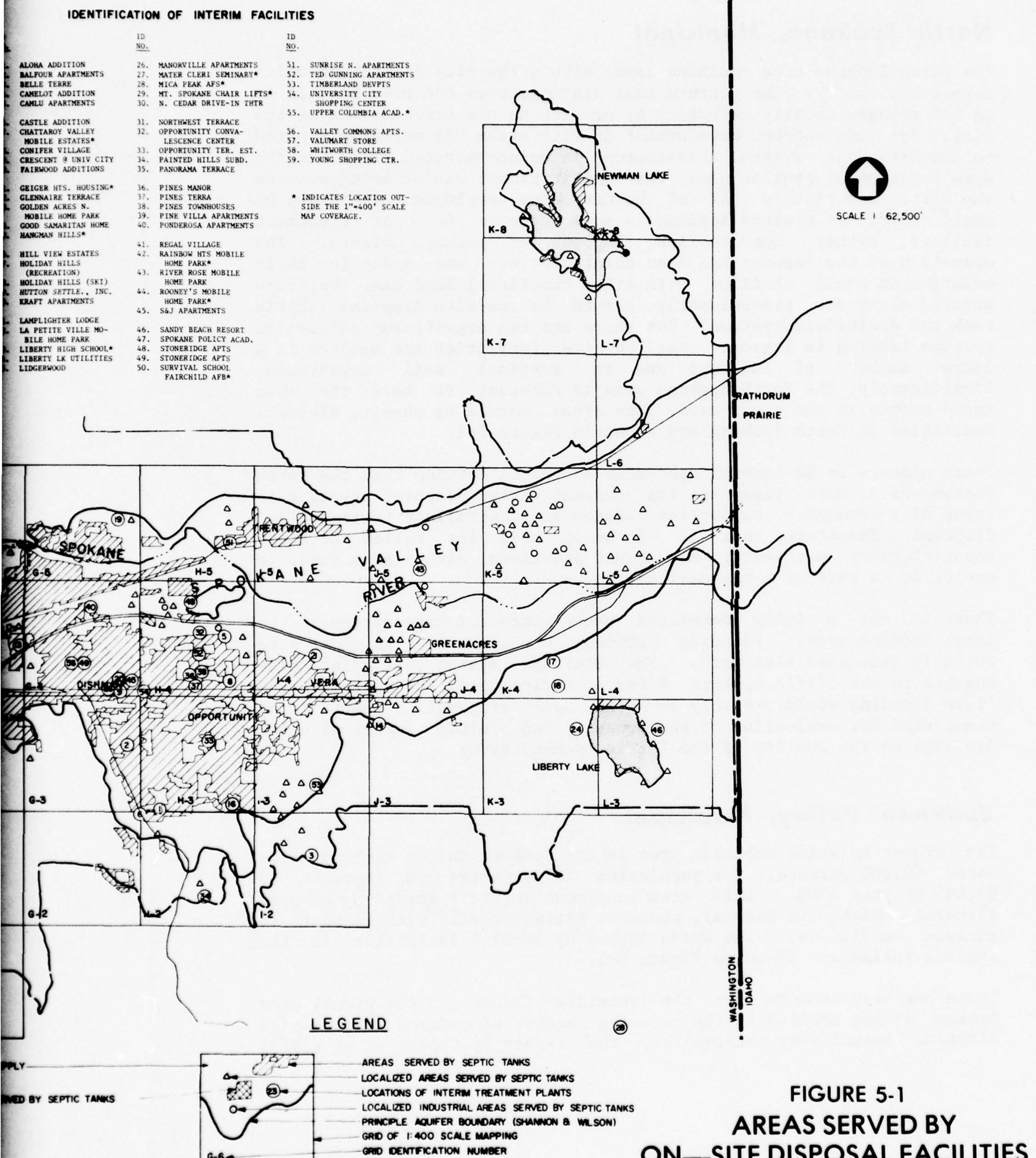


FIGURE 5-1
AREAS SERVED BY ON—SITE DISPOSAL FACILITIES

1

was one of the earliest responses to the question, "Is or will the continuation of on-site disposal in Spokane Valley cause unacceptable degradation of the aquifer?" The Crosby report was widely interpreted to indicate that no contamination was taking place. Routine water quality analysis from pumped wells fail to show any categorical evidence that pollution is taking place.

There is an unmet need to evaluate the existing and projected impact on the important groundwater body underlying this large suburban development served by on-site disposal. If such an evaluation should show that there is or will be an unacceptable threat, then there is an unmet need for abatement. Abatement methods could include measures ranging from non-structural control of housing density or location to construction of a community sewage collection system with central treatment facilities. If there is a need for community collection, there is the further need to determine whether this service area is best served as a complete entity or as part of a regional system.

In general, the developed areas of the Spokane Valley are drained by infiltration into the highly permeable soils, either immediately at the point of occurrence or by collection to numerous dry wells. From a drainage standpoint this system is functionally satisfactory, with some exceptions which are discussed elsewhere. There is no direct impact of urban runoff on surface waters. The impact on groundwater is unknown. There is, therefore, an unmet need to evaluate the present and future impact of urban drainage by percolation on the groundwater. If an unacceptable impact should be found, then there would be the need for alternative abatement measures.

Regional, Municipal

A regional plan for municipal wastewater management for the Spokane Metropolitan Region did not exist prior to this study. There was no plan which determined whether the various service areas should provide for wastewater management separately or in any variety of combinations. There was no plan which determined the optimum mode of ultimate wastewater disposal for various service areas and their combinations. Likewise, there was no regional plan for the disposal of the solids resulting from treatment of these wastewater flows.

This planning problem is one of the primary targets addressed in this study. The status of the individual elements of the regional system have been described above.

Separately, the City is adequately provided for with regard to 1983 disposal standards by the committed improvements and upgrade of the City STP and by the planned program of correction to the combined sewer overflow problem. The forecast growth of the City itself is relatively small and its projected flow of 34 mgd at year 2000 well within the capacity of the projected City STP expansion to 40 mgd. There is therefore some projected unutilized capacity considering the

City alone. Possible service to unspecified "other" service areas was considered in the selection of the design capacity of the City STP. Refer to Bovay (1973). The design of the upgraded facility also provides for possible future expansion to a capacity of 60 mgd.

North Spokane, immediately adjacent to the City service area, has no community treatment facility but has an unmet need for community sewerage and treatment. The forecast flows for this area range from 2.4 mgd to 5.8 mgd ADWF at year 2000.

Spokane Valley, adjoining the City service area on the east, likewise has no existing community treatment facility. Whether or not it has a confirmed unmet need for community sewerage and treatment is at issue. The uncertainties surrounding this issue and the fact that they might not be resolved for some time after the completion of this study indicates the need for a flexible approach in the analytic and planning process. Therefore, since there is a possibility that a community sewerage system might be required for all or a portion of the Spokane Valley, its impact and place in a regional wastewater management plan must be analyzed both ways; as a required element and as not required or indefinitely postponed. The forecast flows for Spokane Valley range from 7 mgd at 1980 to 10 mgd ADWF at year 2000.

The unmet need for a regional wastewater management plan, therefore, must address an area consisting of three major elements, the City, North Spokane and Spokane Valley. The major goal of analysis is to determine whether it is most beneficial on a regional basis to provide for separate treatment and disposal or for combined treatment and disposal, and if so, what elements should be combined.

It is not within the scope of this study to develop detailed wastewater management plans for communities outside the urban planning area. It is, however, necessary to consider the impact of combining any nearby community with the regional system if such an arrangement would be beneficial. The only communities of sufficient size or proximity that could be considered in this connection are the communities of the West Plains area, including Cheney, Medical Lake, Airways Heights and Fairchild Air Force Base. These communities have unmet needs for wastewater management improvements at present and could be faced with severe problems in the future if they experience growth from an improved water supply or if there is strict interpretation and enforecement of 1983 disposal criteria for small communities. The issue would then involve the question of whether these unmet needs are best served independently of or in combination with the urban area. This study considers the possible impact on the urban regional plan of incorporation of West Plains communities.

A regional wastewater management plan inevitably creates the need for a regional plan to deal with the solids separated in the process of wastewater treatment. This problem is addressed following and based on the results of analysis of the regional wastewater problem.

Industrial

There are no industries within the City with separate discharges; all discharge to the City municipal system. The process component of these flows is estimated to be approximately 2.6 mgd or approximately 12 percent of the residential component. The forecast growth indicates that industry inside the City will be substantially of the same character as at present and discharge will increase to about 4.0 mgd at year 2000, becoming 16 percent, a slightly higher proportion of the residential-commercial component. The needs of industrial flow tributary to the City municipal system are met through a combination of the municipal treatment capability and controls imposed on the industries through industrial cost recovery (Bovay 1974b). There are no existing forecast unmet needs for industrial wastewater control within the City that cannot be met with the committed municipal facilities and existing controls on industrial dischargers.

Outside the City there are industrial wastewater discharges separate from municipal systems. At present pollution abatement through the NPDES permit system is providing adequate control. The estimated effluent load at year 2000, assuming comparable industry and level of treatment is, for example, 1600 pounds per day of BOD and 91 pounds per day of phosphorus. These values compare with an estimated output from municipal sources for the entire urban area of 11,000 pounds per day of BOD and 600 pounds per day of phosphorus, both at 85 percent removal. It can be seen that the potential pollution load of typical municipal parameters from separate industrial discharges in the Spokane area is small compared with the municipal load. The danger from industrial discharges is typically in parameters not usually of concern in municipal wastewater, such as heavy metals and toxic organic chemicals, and it is these items that are the primary target of the NPDES permit system and its accompanying reporting and monitoring. Assuming continued operation, surveillance and enforcement of the NPDES system, there will be no general unmet need with regard to industrial discharges. Specific minor exceptions are discussed below. The area of unmet need would be in evaluating the potential benefit of consolidation with a municipal system if available, either as a cost consideration or for water quality or environmental reasons.

There are five major industrial waste dischargers in the study area which presently have disposal separate from municipal systems: (1) Kaiser Trentwood, (2) Inland Empire Paper, (3) Spokane Industrial Park, (4) Hillyard Processing and (5) Kaiser-Mead. Refer to Figure 5-2 for locations of industrial and municipal dischargers.

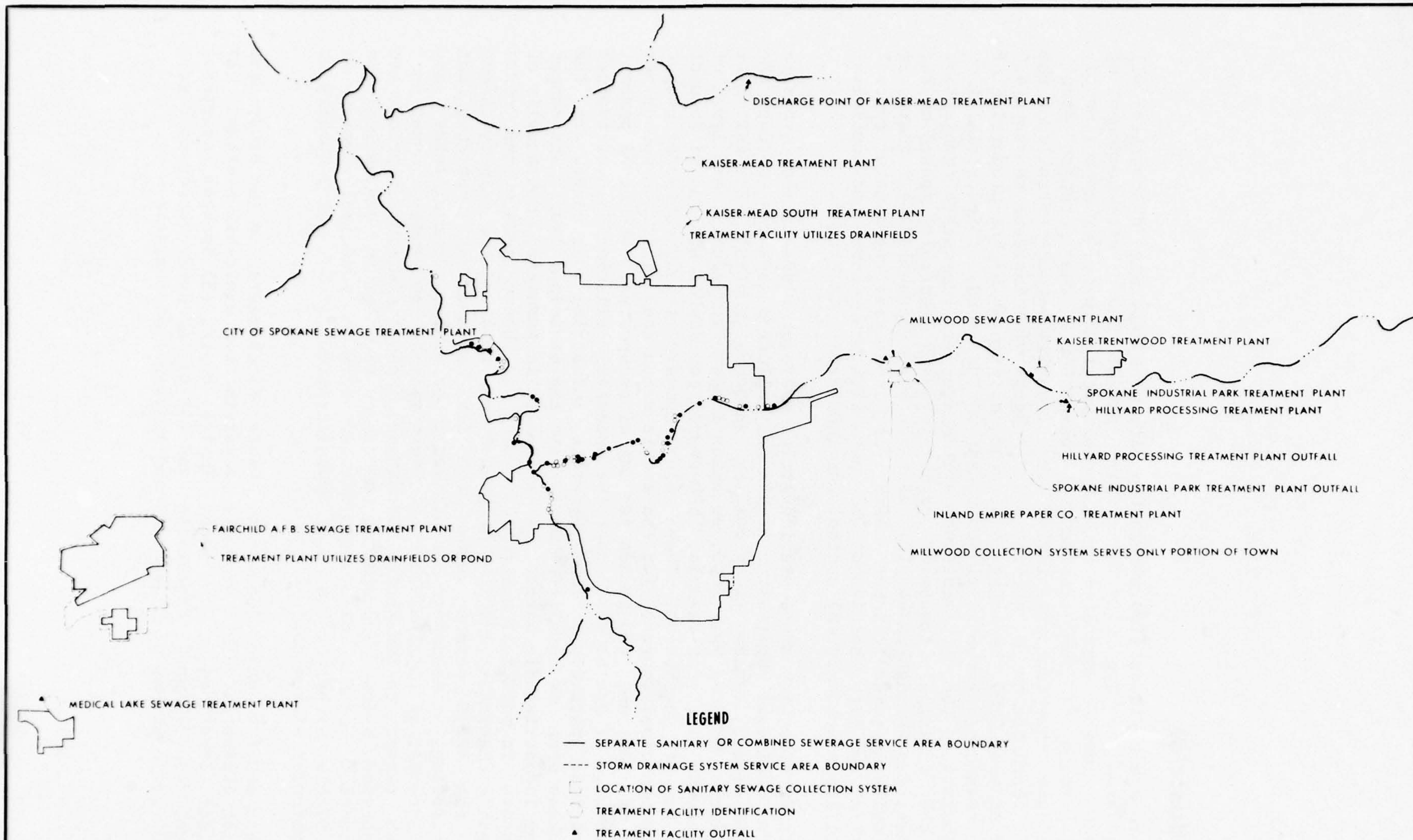


FIGURE 5-2

MUNICIPAL AND INDUSTRIAL WASTE SOURCES

The Kaiser Trentwood discharge has four components; sanitary, chemically contaminated, cooling water and storm drainage. The cooling water discharge is approximately 23.3 mgd and would not benefit by combination with a municipal system. The industrial wastewater which is chemically contaminated is approximately 0.43 mgd and the contaminants are oil, phosphate and chromium. The industrial component would require pretreatment before discharge to a municipal system and and would not benefit by municipal treatment. The sanitary component is estimated at 157,500 gpd. If there were a municipal sewer very nearby, it would undoubtedly be less costly to divert this flow to a municipal system, but its extremely small size would not justify much conveyance expense as compared with a small package treatment facility. The volume of storm runoff is not available nor is there an analysis of associated pollutant load. The roof and site area indicate that storm runoff is of the order 200 acre feet per year or an average of 0.2 mgd with 24-hour peaks of 7.5 mgd rate. Except for the sanitary component there appears to be no potential benefit for combining any of the Kaiser Trentwood waste discharges with a municipal system. Continuation of separate treatment and disposal is suggested.

An item of special concern with regard to Kaiser Trentwood is the sudden deterioration of the chemical quality of their Eastgate well (USGS number 25/44-2Q1) between September of 1973 and June of 1974. In this period the conductivity rose from 320 to 767, chlorides from 3.0 mg/l to 130 mg/l and chromium from none to 120 ug/l. This deterioration has not been explained to date. The Kaiser Trentwood industrial waste lagoon is approximately 3/4 mile west where the groundwater contour is almost 10 feet below the contour at the well. This makes it impossible for the waste lagoon to be the source. The Spokane Industrial Park (SIP) treatment facility is approximately 3/4 mile south of the well and on approximately the same groundwater surface contour, making it close to impossible as a source. Spokane Industrial Park itself is east of the Kaiser Eastgate well and on the groundwater flow line which passes through the well, but SIP is sewered. It is suggested that an investigation be made to determine the source of this groundwater pollution. This is the only grossly detectable case of severe groundwater pollution in the Spokane Valley and understanding its mechanism should have significance for the entire valley.

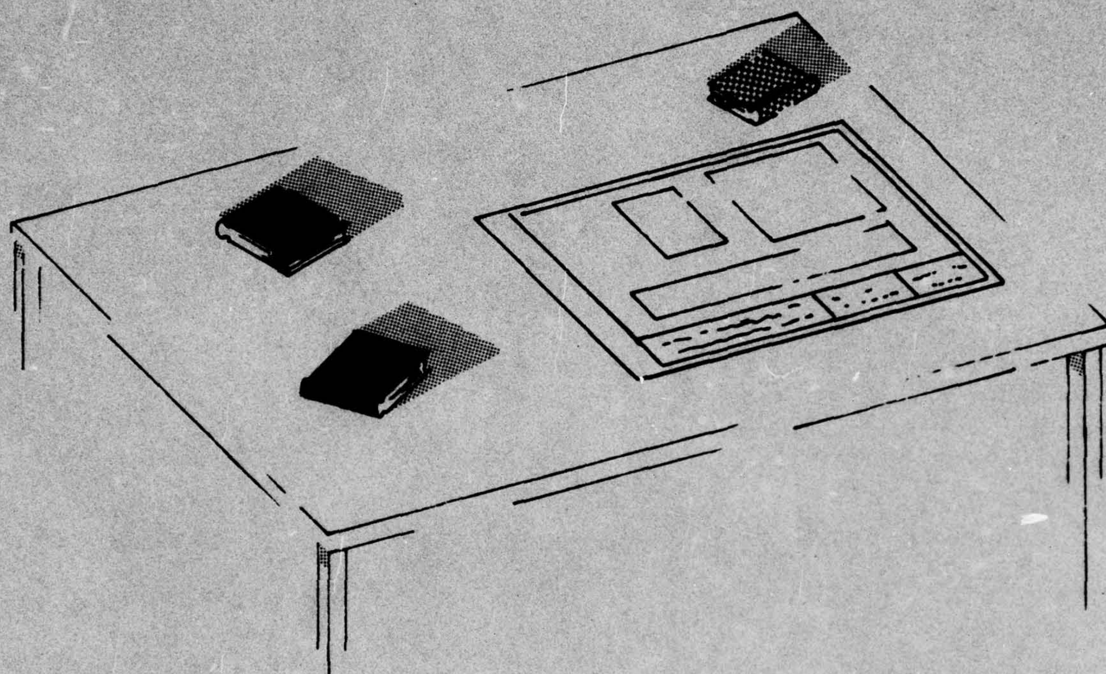
Inland Empire Paper has a total discharge of approximately 3.3 mgd of which about 1.0 mgd is cooling water. The industrial waste component is from pulp and paper processing and the permit limits the discharge to 1400 pounds of BOD per day. In 2.3 mgd this is equal to 73 mg/l of BOD. The Inland Empire Paper wastes, with pretreatment to 73 mg/l level, would not be incompatible with municipal treatment which could provide benefits in both quality of effluent and costs. Inland Empire Paper is located adjacent to a proposed trunk sewer and about 1 mile from a possible Spokane Valley treatment plant site. It is suggested that, if a Spokane Valley community treatment facility is implemented, consideration be given to incorporating the industrial waste component of the Inland Empire Paper.

Spokane Industrial Park, owned and operated by Washington Water Power Company, leases sites to 64 tenant industries and provides collection and treatment of the sanitary and industrial wastes. In general, the tenant industries are dry industries and have only sanitary wastes. The wet industries have waste discharge permits that require pretreatment that would make their discharges compatible with a municipal type treatment facility. The total flow could benefit by the existing advanced treatment and control available in a larger municipal facility. SIP is about 1-1/2 miles from the nearest proposed Spokane Valley trunk sewers and would require a pump station. It is suggested that SIP be considered for incorporation into any Spokane Valley community collection and treatment system.

Hillyard Processing has industrial waste flows that average approximately 0.6 mgd. The pollutants which originate from washing of aluminum dross are inorganic chemicals including chlorides and ammonium hydroxide. High pH is also a problem. These wastes are not of a nature that would benefit from municipal type waste treatment and are better handled by specific separate facilities. On 1 July 1975 Hillyard Processing initiated a complete recycle and reuse of its process wastewater. Hillyard Processing wastes are not suggested for incorporation into a community system.

Kaiser-Mead has three wasteflow categories; sanitary, softener regeneration and cooling. The cooling water flows represent the majority of the flow, totaling approximately 5 mgd. The softener regeneration wastes total 16,000 gpd, presumably high in chlorides. The sanitary flow is 185,000 gpd. The treated sanitary wastes are combined with the untreated softener regeneration wastes and cooling water and discharged to Peone Creek. There would be no benefit to sending uncontaminated cooling water to a municipal facility. Similarly, the salt solution from softener regeneration would receive no benefit. There would be benefit from sending the sanitary flow to community treatment for two reasons; first, the better process control at a larger facility and second, the effluent would be removed from Peone Creek. This treated sanitary discharge is probably the source of the high coliform counts observed in the lower reaches of the Little Spokane River. There does not appear to be any detrimental effects from the chlorides discharged into Peone Creek, but there may be some benefits to its removal and discharge to a point of greater dilution. It is suggested that the sanitary component be diverted to the North Spokane community system when it becomes available.

The cooling water flow makes up a significant part of the summer flow of Peone Creek, but at the relatively high temperature of 20° C. Supplemental well water to reduce the temperature may be desirable for the particular biologic community sought in Peone Creek. This is a highly specialized consideration that could be explored by DOE in reformation of their permit criteria.



SECTION 6

ALTERNATIVE PLANS FOR REGIONAL WASTEWATER MANAGEMENT

6. Alternative Plans for Regional Wastewater Management

Goals of a Regional Plan

The goal of a regionalization plan is to determine the optimum combination of service areas, treatment techniques, disposal methods and specific treatment and disposal sites. The optimization is to include consideration not only of cost-effectiveness but of all those economic, social and environmental factors which are important to quality of life in the area.

Formulation of Alternative Plans

Under disposal criteria it has been shown that there are a number of acceptable techniques for meeting BPWTT (1983) disposal criteria for each of the two basic disposal categories, surface water and land application. It is also shown that certain land application techniques would be acceptable for interpreted criteria to meet 1985 goals and that 1985 criteria could be met for surface water disposal by the addition of advance physical-chemical processes. Thus, there is an array of treatment-disposal combinations for 1983 criteria and an array for 1985 criteria. In addition to the generalized treatment-disposal combination, there are the variations for site specific conditions.

Under the description of the urban plan area it has been shown that there are three basic service areas: the City, North Spokane and Spokane Valley.

The regionalization alternatives for three elements lead to five possible combinations of elements: (1) each element separate, (2) all elements together, (3) City and North Spokane combined, with North Spokane separate and (5) North Spokane and Spokane Valley combined, with the City separate.

Thus, the possible total array of alternative plans would be generated from combining all possible site specific treatment-disposal combinations with the five possible service area combinations. A single step compilation and evaluation of all possible combinations is burdensome

and tends to obscure the decision process. For these reasons a stepwise approach of screening and combination is utilized beginning with the screening of treatment-disposal combinations.

For surface water disposal to 1983 standards, the optimum treatment technique for the size of plants involved is selected to be activated sludge process secondary treatment. For surface water disposal to interpreted 1985 standards, the following processes are added to the secondary process: nitrification-denitrification by activated sludge process and anaerobic methods, respectively, mixed media filtration, carbon adsorption, ozone disinfection and reaeration.

Due to the lack of sufficient land areas with relatively impervious soil and 2 to 6 percent slope, the overland flow technique of land application is eliminated. Irrigation and infiltration are such different land application techniques that both are considered. Both land irrigation and infiltration-percolation when properly applied will satisfy both 1983 standards and interpreted 1985 standards.

Thus, three basic treatment-disposal combinations are selected to satisfy 1983 and interpreted 1985 criteria. For 1983 criteria, the three systems are as follows, with an abbreviation symbol for each:

sw - surface water disposal following secondary treatment, 85 percent phosphorus removal and disinfection

li - land application to irrigation

lp - land application to infiltration-percolation

Similarly, for interpreted 1985 critera, the three systems are:

swt - surface water disposal following advanced treatment consisting of secondary and phosphorus removal plus nitrification-denitrification, filtration and carbon adsorption

li - land application to irrigation

lp - land application to infiltration-percolation

There are no present significant opportunities to recycle water in the study area other than as land irrigation is considered a recycle of wastewaters. Disposal criteria for recycle require that any wastewater treated for recycle must meet as a minumum the requirements for disposal subsequent to reuse. This means that recycle is simply a "pipe" between the treatment process and the ultimate disposal. Therefore, recycle can effect comparison of basic alternatives only if it creates a net benefit. For example, if an opportunity for recycle

were found and ultimate surface water disposal were contemplated after the recycle use, the renovated wastewater would have to be furnished to the recycle user at a quality suitable for surface water disposal. This would impact the basic surface water disposal alternative only if there were a net return to the treating agency after conveyance to the user. With the abundant supply of water available, it is unlikely that anyone would want to pay a premium for conveyance to them of reclaimed water.

The subalternatives involved in the techniques of utilizing both land application methods are extensive and largely untried. It was pointed out under disposal criteria that the EPA guidelines are not specific and that there is no adopted DOE policy covering many important facets of land application. In order to formulate specific alternatives that can be subjected to cost-effectiveness and environmental evaluation, it is necessary to select criteria for this study by applying judgment to literature data.

For both irrigation and infiltration, the appropriate level of pretreatment is selected as secondary treatment, either by site intensive facilities such as activated sludge or by lagoon treatment. It is recognized that there are no guidelines or statutes prohibiting application of primary treated sewage. The selection made herein is for functional reasons. For infiltration-percolation, the choice is dictated by clogging potential of primary effluent. For irrigation, the considerations include maintenance of long pipelines, odor at the point of discharge, between season reservoir storage, sprinkler equipment maintenance and superiority of disinfection.

The guidelines are clear in discouraging irrigation application except during the growing season. This policy is adopted and all irrigation proposals provide for either storage or alternative disposal during the off season.

For infiltration-percolation, the problem of protection of the groundwater from excessive nitrates is recognized by specific locations. Where the disposal site would expose an aquifer that has unlimited access by groundwater users, it is assumed that nitrification-denitrification are required additions to pretreatment before application. All of the Spokane Valley aquifer upstream from the confluence of the Little Spokane and Spokane Rivers is regarded in this category. Percolation sites downstream from the Little Spokane confluence are regarded as having access to groundwater limited or controllable. For these sites it is assumed that nitrification-denitrification is not required.

The five possible service area combinations described above actually contain seven possible operating entities: the three service areas independent of each other, the three service areas paired with each other and all three combined; that is, there are seven service entities each of which has a choice of the three disposal categories,

making a total of 21 possible service-area and disposal combinations. These 21 alternatives as listed in Table 6-1 are the building blocks for all possible systems to serve the entire urban planning area. The ways in which these 21 service area-disposal subsystem alternatives can be combined with each other to form regional systems result in a matrix of 57 regional systems applicable to each level of disposal criteria. In addition to the two levels of disposal criteria, it is also desirable to determine the rank of alternative systems for both seasonal and year-round phosphorus removal applied to surface water disposal.

TABLE 6-1

POSSIBLE COMBINATIONS OF
SERVICE AREA ENTITIES WITH DISPOSAL ALTERNATIVES

	Disposal Alternative		
	Surface Water	Land Application	
Service		Irrigation	Percolation
Entity	sw	li	lp
C	C-sw	C-li	C-lp
NS	NS-sw	NS-li	NS-lp
SV	SV-sw	SV-li	SV-lp
C+NS	(C+NS)-sw	(C+NS)-li	(C+NS)-lp
C+SV	(C+SV)-sw	(C+SV)-li	(C+SV)-lp
C+NS+SV	(C+NS+SV)-sw	(C+NS+SV)-li	(C+NS+SV)-lp
NS+SV	(NS+SV)-sw	(NS+SV)-li	(NS+SV)-lp

Legend: C = City of Spokane
NS = North Spokane
SV = Spokane Valley
sw = surface water disposal
li = land application, irrigation
lp = land application, percolation

Each of the 21 building block elements that make up these systems in turn has subalternatives generated by the specifics of site selection and treatment technology associated with specific sites. Generation of optimal plans for each of the 21 building block elements form the basis for their aggregation into regional systems to be considered in the selection process.

Site Specific Considerations for City Combinations

For all service area combinations which involve the City, the existence of the committed improved plant is of paramount importance. This improvement is a sunk cost relative to this study. Economically, this rules out consideration of any site other than the existing site. The relative size of City flows compared with North Spokane and Spokane Valley would strongly favor conveyance of these areas to a site nearest the City in any case. Therefore, all plans in which the City is a combined service-area element utilize the City STP as it will be when the committed improvements are completed.

The City STP as improved will include solids-handling facilities consisting of anaerobic digestion, vacuum filtration and sanitary landfill disposal. For this reason and the fact that this system is one of those most widely used, it is adopted as the typical sludge disposal method for the purpose of initial screening. Other sludge disposal alternatives are considered in a subsequent step.

All plans in which the City is a combined element therefore involve conveyance facilities from the other areas to the City STP. The natural point of concentration in the North Spokane area is in the vicinity of the Fish Hatchery. Substudies on conveyance indicate that an optimum system of conveyance from the North Spokane area would consist of pumping from at or near the natural point of concentration south to Francis Avenue in the City and thence westerly on Francis Avenue to approach the City STP via Assembly Street. Parts of the North Spokane area west of Five Mile Prairie would be brought in by separate conveyance facilities.

The City STP has adequate capacity to handle the City and North Spokane to year 2000 without further expansion. To handle Spokane Valley or both North Spokane and Spokane Valley, an expansion of capacity would be required, utilizing the provisions incorporated in the present plan to expand to 60 mgd within the site.

The natural point of concentration of Spokane Valley is in the vicinity of Felts Field. Conveyance to the City would involve a force main tentatively sited along an alinement following Mission Avenue and Northwest Boulevard.

Since pretreatment to secondary level is to be provided for both land application alternatives as well as for surface water disposal, the City STP is utilized for all disposal alternatives for all service area combinations with the City. In summary, therefore, all plans involving combination with the City involve conveyance to and use of the City STP. The facilities for land application disposal alternatives are additive to these basic facilities which provide for surface water disposal.

Site specific considerations for land application are critical to both formulation and evaluation. Those for disposal by irrigation are discussed first.

To put land disposal by irrigation into perspective, it must be recognized that the treated wastewater potential from the City alone or in combination with the rest of the urban planning area will equal or exceed the current water consumption for agricultural irrigation for the entire study area. The estimated 1980 wastewater flow, not including urban runoff, is 34,000 acre feet per year for the City alone. The estimated current water consumption for agricultural irrigation for the entire study area is 36,000 acre feet per year, of which 21,600 are in the Spokane Valley, 6500 are in the Little Spokane Valley and the remaining 7900 are throughout the remainder of the study area. For the entire urban planning area at the design year 2000, the forecast wastewater potential is 56,000 acre feet per year or more than 1.5 times the current agricultural irrigation use for the entire study area. This means that irrigation alternatives must look toward bringing additional lands under irrigation.

Potential irrigation sites other than the Spokane Valley are described in the U.S. Bureau of Reclamation (1973) report to the City of Spokane. The USBR report forecloses consideration of the Spokane Valley on the grounds that it would be rejected by public opinion. This study is based on the premise that all technically feasible alternatives that can meet Federal and State requirement must be kept open for evaluation through the decisionmaking process. The Spokane Valley is therefore added for consideration.

Additional irrigation sites are investigated under alternatives which do not include the City and therefore require substantially smaller areas.

The sites described by the USBR as having potential are listed below with their maximum areas and elevation range. Similar data for Spokane Valley have been added.

Location	Elevation Range, Feet	Maximum Area, Acres per USBR
Fairchild	2300 to 2420	5,000
Down River	1760 to 1860	2,700
North (Little Spokane Valley)	1850 to 2000	80,000
Scabland	Not given	Not given
Riverbench	Not given	Not given
Spokane Valley	2000 to 2100	10,000

Screening of these alternatives was carried out based on considerations of the following factors:

1. Area availability
2. Crop and income
3. Soil
4. Groundwater
5. Availability of an off-season storage site
6. Relative distance and elevation
7. Availability of other water supply

Based on these considerations, the Little Spokane Valley is selected as the optimum site for City combined alternatives. The specific area of the Little Spokane Valley selected is the Williams Valley for its relative proximity to the City and to a possible storage site. Preliminary geological reconnaisance indicates that a reservoir could be created by construction of an earth or combination earth and rock dam. The off-season storage reservoir is a major feature of any irrigation plan since the required volume is greater than that of Newman Lake.

The irrigation disposal alternative for City combined alternatives would then include, in addition to conveyance to and utilization of the City STP, pump stations and force mains approximately 20 miles long to a major storage reservoir. Also included are distribution facilities from the storage reservoir throughout the irrigated area to provide a connection at each 40-acre parcel and finally sprinkler irrigation facilities on the irrigated site itself.

The site requirements for infiltration-percolation are much less in area than for irrigation due to the higher unit application rates and the fact that operation is year-round. The primary constraint is location of soils having the required high degree of permeability. The nearest lands of required permeability are the surfaces of the Spokane Valley aquifer. The most advantageous site is the nearest and one which requires the least pretreatment. The terraces on the north side of Long Lake fulfill these requirements and are selected as the optimum location for City combined alternatives. Being downstream from the Little Spokane confluence, nitrification-denitrification pretreatment is not required. Infiltration-percolation disposal requires more than the simple availability of a spreading pond. Optimum operation is obtained through cyclical applications in a controlled manner. Therefore, the facility includes multicellular ponds with the necessary piping and control structures to achieve cyclical operation.

Infiltration-percolation disposal for City combined alternatives therefore includes, in addition to conveyance to and utilization of the City STP to provide secondary pretreatment, pump stations and force mains approximately 13 miles long to the percolation site plus all the above described improvements to the site itself.

Site Specific Considerations for North Spokane

Alternatives in which North Spokane is not combined with the City or Spokane Valley require selection of specific sites for all three disposal options. For surface water disposal, the problem is one of finding a site with adequate dilution. Forecast flows for North Spokane by year 2000 will be too great for acceptable dilution in the Little Spokane River without advanced treatment. The nearest site with adequate dilution is the Spokane River at the point of concentration near the Fish Hatchery or at the confluence point of disposal. In either case conveyance is required over the same distance.

Due to the relatively small flow from the North Spokane area as compared with the City, smaller candidate land areas can be considered for land application by irrigation. In addition to the alternative areas described above, it is possible to consider nearby land in Peone and Five Mile Prairies and the north bank of the Little Spokane River. Five Mile Prairie is eliminated because it is at an elevation of 2360 to 2400 feet corresponding to a lift of approximately 500 feet above the service area, is scheduled for some low density residential development and has only enough area for disposal of part of the total annual flow. Land areas on the north bank of the Little Spokane River are in the form of steep canyons unsuited for agriculture. The only kind of irrigation feasible on such steep land would be forest irrigation at very low rates taking very large land areas in proportion to flow. The available lands are also at excessive elevations compared to Peone Prairie. Since Peone Prairie is nearer than any of the sites considered for the City and is more suitable than other local areas, it is selected as the application site.

There are sites on the edge of Peone Prairie where the required storage can be developed for seasonal effluent storage to utilize the total annual flow for irrigation.

Secondary treatment, the required pretreatment for irrigation application, could be achieved by three subalternatives: (1) site intensive treatment at the point of concentration, (2) primary treatment at the point of concentration followed by lagoon treatment in Peone Prairie or (3) complete lagoon treatment in Peone Prairie.

Transport of raw sewage to Peone Prairie for full lagoon treatment, with first stage mechanical aeration, is selected as the most cost-effective subalternative. The subalternative of using irrigation for only seasonal disposal with surface water or percolation as off-season dispsal is not compatible with full lagoon treatment at a location remote from alternative disposal opportunities. A complete

land irrigation system for North Spokane, then, utilizes conveyance to Peone Prairie, lagoon secondary treatment, seasonal storage, distribution and sprinkler system.

For infiltration-percolation disposal, it is possible to consider sites on the surface of the outwash gravels where adequate space is available. Such an area is available near the Little Spokane confluence and is selected for this alternative. Since the site is upstream from the confluence, nitrification-denitrification are provided as elements of pretreatment. The complete system would consist of secondary treatment with nitrification-denitrification, conveyance and infiltration-percolation facilities as described above.

Considerations for Combining North Spokane and Spokane Valley

A substudy of the conveyance cost in both directions indicates that the least costly system is conveyance of North Spokane wastewater to Spokane Valley, the smaller flow of North Spokane more than offsetting the higher lift. Other considerations, however, mitigate against this selection except for surface water disposal.

A surface water disposal alternative for North Spokane and Spokane Valley combined would consist of conveyance facilities from the North Spokane point of concentration to the Spokane Valley. Secondary treatment facilities with phosphorus removal would be provided for the combined flows in the vicinity of Felts Field.

For land irrigation, the availability of appropriate sites for lagoon treatment, seasonal storage and irrigation are more significant than the differential in conveyance costs north to south versus south to north. The availability of suitable land for the three interrelated functions in the Peone Prairie area dictates a conveyance from Spokane Valley north in this case, involving pumping from the natural point of concentration north across the river and along the eastern edge of the City. Conveyance from North Spokane point of concentration east also involves pumping and force main. The treatment and disposal facilities would consist of lagoon treatment followed by seasonal storage in an open reservoir created by an earth dam across the mouth of a canyon bordering Peone Prairie. Distribution piping and sprinkler facilities complete the disposal facilities.

For rapid percolation disposal, in order to avoid percolation to the Spokane Valley aquifer upstream from major withdrawals for municipal use, it is necessary again to use a site in the north rather than the south. The selected site is as selected for North Spokane separately, near the Little Spokane confluence. Treatment facilities providing secondary treatment and nitrification-denitrification would be provided either at the percolation site or near the North Spokane point of concentration. Conveyance for Spokane Valley would again involve pumping from the point of concentration, across the river and north along the east side of the City.

Considerations for the Spokane Valley Alone

For surface water disposal, the primary site consideration is to locate the effluent discharge well downstream from the main City wells at Parkwater. The reason for this is that there is an exchange from river to the groundwater at high river stage and presence of the river water mixing with the groundwater is evident in City well water quality at such times. The City wells are downstream from the Spokane Valley natural point of concentration near the east end of Felts Field so this requirement means either an effluent pipeline or an outfall sewer to approximate River Mile 79.

The need for suitable sites for irrigation and percolation disposal causes the same selections to be made for Spokane Valley alone as previously described for combinations of North Spokane and Spokane Valley. For irrigation the system would consist of conveyance to Peone Prairie for lagoon treatment, seasonal storage and irrigation. For rapid percolation the system would consist of treatment at the point of concentration, secondary plus nitrification-dentrification and conveyance of treated effluent to the vicinity of Mead for infiltration.

The Field of Candidate Plans

The result of making site specific selections for the 21 combinations of service area and treatment-disposal techniques is a series of plans sufficiently well defined to form the basis for preliminary cost estimates and to permit evaluation of their probable economic, social and environmental impacts. It is possible to combine these 21 plan elements into 57 different combinations to provide for the entire urban planning area including the City, North Spokane and Spokane Valley. If Spokane Valley is not included, the 21 basic plan elements are reduced to nine and the number of combinations to serve the City and North Spokane alone to 12.

Therefore, a field of 57 candidate plans evolve from a process which has included preliminary screening of treatment techniques and site specific considerations. The consideration of subalternatives generated by combination with various solids disposal alternatives is set aside until screening for wastewater concerns is completed. Subalternatives which must be considered and which must be additive to the fundamental 57 candidate plans are the consideration of two uncertainties, the need for seasonal versus year-round phosphorus removal and the consequences of interpreted 1985 criteria being imposed at some later date.

Since the issue of whether seasonal or year-round removal will be required undoubtedly will not be resolved until full-scale operation of the committed City STP is begun and tried, the issue will remain unresolved until after completion of this study. Seasonal versus year-round phosphorus removal significantly affects the operating costs of all surface water disposal. Therefore, there must be two cost-effectiveness comparisions for each plan element involving surface water disposal to determine if this consideration changes relative rank.

The goal has been stated above to protect the Federal financial interest by making sure that a plan of action selected to be optimal on the basis of 1983 criteria would not, in the long run, be less than optimal if more severe criteria as represented by interpreted 1985 criteria are instituted at some future date. To make this determination, it is necessary to make an assumption of a specific date at which such criteria might be instituted and test the ranking of candidate plans under conditions of making the necessary transition at that date. The selected date for the transition is year 1990.

Two other subalternatives are selected for consideration to test specific concerns. One is an irrigation plan for City combined elements utilizing surface water disposal during the winter season to avoid the cost of seasonal storage and use the nearby limited irrigation site west of the City. The second is to test the effect of reducing pretreatment for irrigation from secondary to primary.

In summary, the candidate plans selected for evaluation are as follows:

1. For the entire urban planning area;

   a. Fifty-seven system alternatives to be ranked considering both seasonal and year-round phosphorus removal under 1983 disposal criteria.

   b. Subalternative ranking of summer irrigation with winter surface water disposal for City combined elements, 1983 criteria.

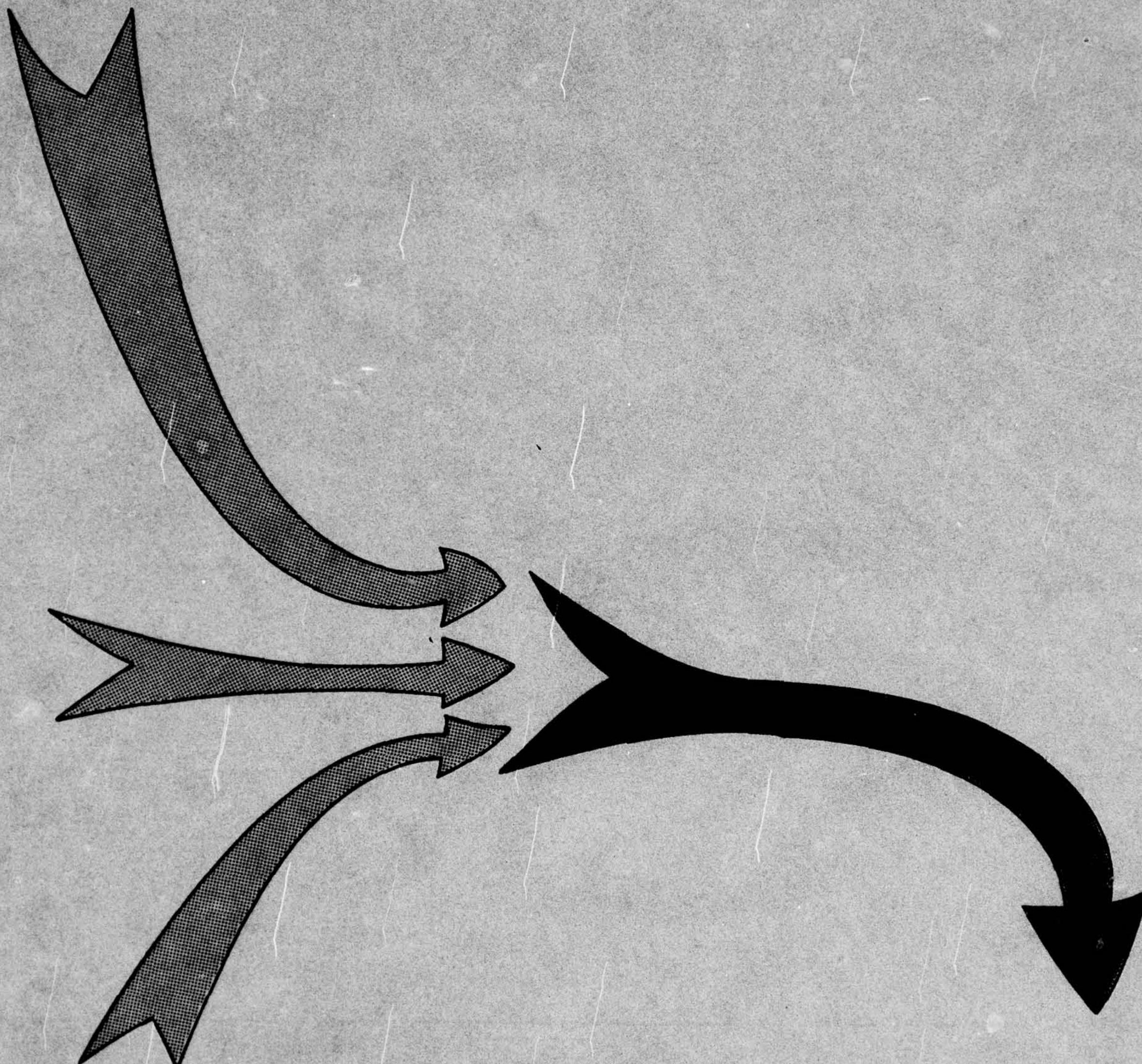
   c. Subalternative ranking of irrigation with primary pretreatment.

   d. Fifty-seven system alternatives to be ranked for upgrading to interpreted 1985 standards in year 1990.

2. For the City and North Spokane only;

   a. Twelve system alternatives to be ranked considering both seasonal and year-round phosphorus removal under 1983 disposal criteria.

   b. Twelve system alternatives to be ranked for upgrading to interpreted 1983 standards in year 1990.



SECTION 7

EVALUATION OF ALTERNATIVE PLANS

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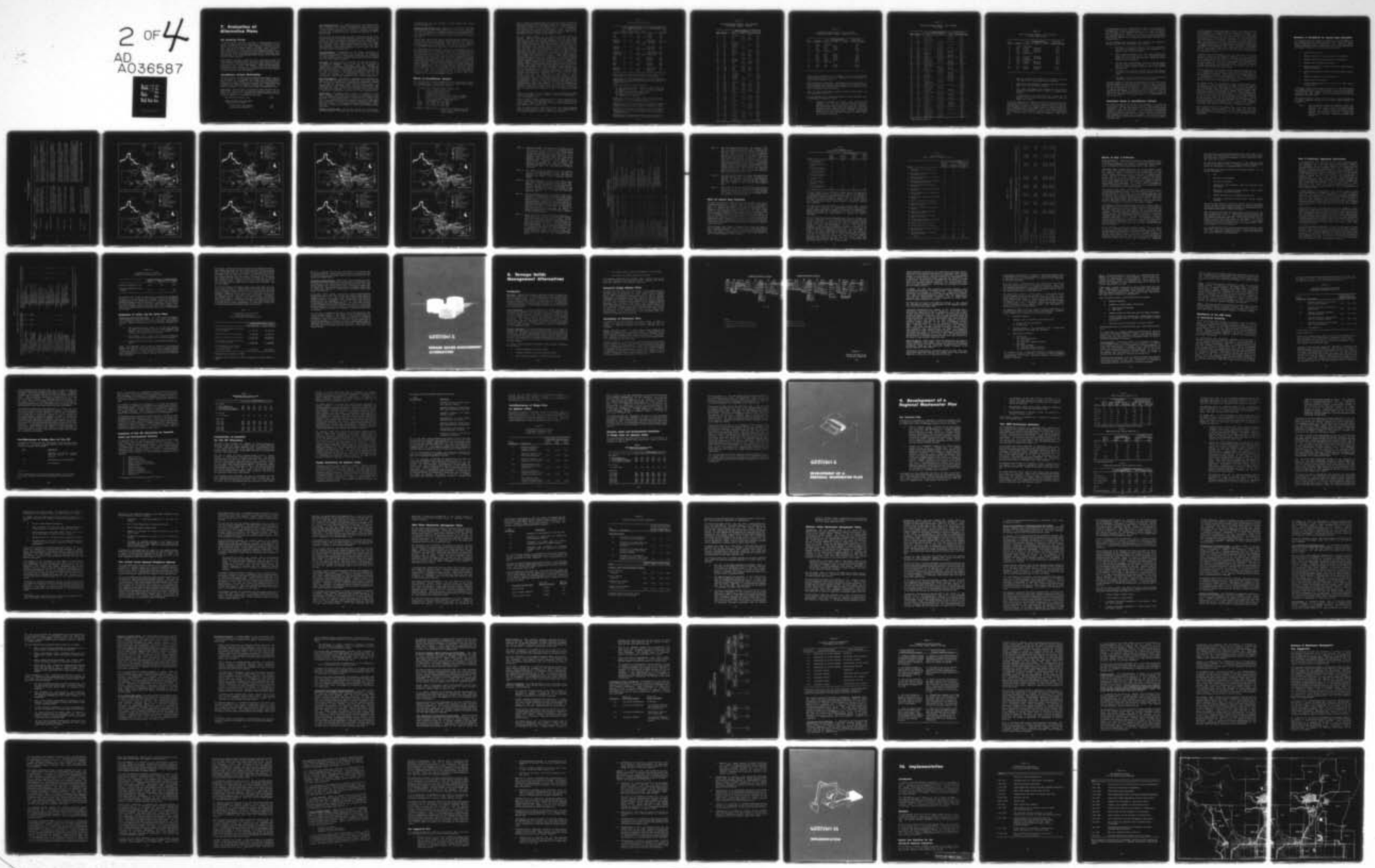


7. Evaluation of Alternative Plans

The Screening Process

As indicated above, significant screening of subalternatives and site specific considerations occur in the process of formulation of alternatives to the point where more formal evaluation processes can take place. The formal processes consist of two major steps, cost-effective analysis and economic, social and environmental evaluation. A final step consists of an evaluation of the leading candidates developed in the formal processes considering areas of uncertainty which are important to the decisionmaking process but that do not lend themselves to formal analysis.

Cost-effective screening is utilized as the first step to screen the large number of possible systems. The goal of the cost-effective step is not to select the lowest cost plan but to select lower cost representatives of the various plan concepts. These selected candidates representing optimal versions of various concepts are then subjected to the second step which considers economic, social and environmental concerns as well as cost-effectiveness.

Cost-Effective Analysis Methodology

The basic criteria for cost-effective analysis where Federal construction assistance is contemplated are stated in the Federal Register, Volume 38 No. 174, September 10, 1973. These data are elaborated and interpreted by sample calculation in Chapter 4 of the EPA publication "Guidance for Facilities Planning," January 1974. Significant criteria as applicable to and used in this study are summarized below.

Price Level. The price level is specified as being that which is current at the time that the cost-effective analysis is made. The following cost indicies are representative of the mid-1974 period which marked the beginning of this phase of the study:

ENR Seattle Construction Cost	2,000
Sewage Treatment Plant and Sewer Construction Cost Index	
Seattle Plant Index WPC-STP	202
Seattle Sewer Index WPC-S	216

Cost Comparison Period. The planning period for cost-effective analysis is specified to be 20 years and the beginning date as the date of initial operation of the system. The earliest possible operation date of any facilities suggested in this study is estimated to be 1980. Therefore, the planning period for cost-effective analysis is 1980 to the year 2000.

Forecast flows and loads to the year 2020 are developed and the facilities selected for the 1980-2000 planning period are evaluated in the context of ongoing requirements, particularly in the acquisition of facilities sites and sizing of interceptor sewers and force mains. All facilities except sewers and force mains are sized, in stages where required, to an ultimate capacity to serve the year 2000 forecast waste load. Sewers and force mains are sized to serve the forecast waste flows for the year 2020.

Staged Development. Consideration of the staged construction is specified as an essential element. Each alternative is examined to see if the minimum cost is obtained by constructing all the required year 2000 capacity at 1980 or whether this capacity should be provided in one or more incremental phases.

Sunk Costs. The capital costs of existing facilities whether used in an alternative management plan or not, are not an element in cost-effective analysis. Facilities which are committed to construction are also regarded as existing facilities. Of specific concern in this study is the enlargement and improvement of the City STP under DOE directive. This facility is regarded as existing and its cost as a sunk cost. Operation and maintenance costs for the facility are included in cost-effective analysis as are any enlargements or improvements subsequent to the initial construction.

Basis for Comparison. Cost-effective comparisons are specified to be made on the basis of present worth or equivalent annual value computed from the total of capital costs, including major replacement, adjusted for salvage value, and annual operation and maintenance costs. The present worth or equivalent annual value are to be computed recognizing the time value of money at the specified interest rate. This study makes the comparisons on basis of present worth of the capital and operation and maintenance costs over the 20-year planning period.

Interest Rate. An interest rate of 7 percent is specified in the above referenced guidelines which refer to the concurrently issued "Proposed Principles and Standards for Planning Water and Related Land Resources" (FR 10 September 1973 Vol. 38 No. 174) for further guidance. As of January 6, 1974, the Seattle office of EPA interpreted these guidelines to indicate that 7 percent is appropriate for current studies to be used in satisfying EPA planning requirements. Therefore, the 7 percent rate is adopted for this study for cost-effective comparisons.

Elements of Capital Costs. Capital costs include not only the construction costs of facilities and the lands on which the facilities

are located, but the costs attendant to design, construction, startup and land acquisition.

Service Life and Salvage Value. Depreciation of physical facilities other than land is recognized by adoption of finite service lives for all structural elements in conformance with the referenced guidelines. Land and rights-of-way are assumed to suffer no depreciation and to have a salvage value at the end of the study period equal to the original price.

It should be noted that the cost of internal sewerage collection systems for areas not already sewered is not included in the costs considered for cost-effective analysis. These costs would be common to all plans except the no action plan. The costs of internal sewerage are considered subsequently under costs of plan implementation.

Land application alternatives are priced on the assumption that all required lands will be purchased and owned by the wastewater management agency and that the net income, if any, from the operation of the land will accrue to the agency. In the case of land application to infiltration-percolation there are no practical alternatives to this arrangement. For irrigation there are many alternatives including contractural arrangements with the present occupants. The selected method gives the cleanest method of accounting for all the costs and revenues involved. Lest the selected method be thought prejudicial against irrigation, it should be noted that for the specific pricing used, the present worth of the 20-year revenue exceeds the purchase price of the land less the present worth of its 100 percent salvage value. In other words, the chosen method is more favorable to irrigation than if it were assumed that the reclaimed water were supplied free to the existing farmers' fields.

Results of Cost-Effective Analysis

The cost-effective analysis is summarized in the accompanying tables and presented below. Abbreviations used in the tables and descriptions in the remainder of this report include:

City STP = City of Spokane Sewage Treatment Plant
C = City of Spokane service area
NS = North Spokane service area
SV = Spokane Valley service area
sw = surface water disposal with secondary treatment
swt = surface water disposal with tertiary treatment
lp = land application to rapid percolation
li = land application to irrigation
sw/swt = sw to 1990, swt after 1990
sw/lp = sw to 1990, lp after 1990
sw/li = sw to 1990, li after 1990

For example: (C+NS)-sw, SV-sw = surface water disposal, City and North Spokane combined, Spokane Valley separate.

Table 7-1 shows the computed costs, as net present worth of the sum of capital and operation and maintenance costs, for a study period of 20 years 1980 to 2000 of the 21 elements which make up the various systems which can serve the urban planning area. Costs are shown for 1983 standards, with seasonal and year-round phosphorus removal where applicable, and for interpreted 1985 standards imposed in 1990 for all alternatives and for certain special subalternatives.

Note that "1983 standards" do not preclude performance beyond the minimum. Therefore, both land application alternatives are listed under 1983 as well as under 1985 standards. The costs listed under 1983 standards are for the designated treatment and disposal system being in force from 1980 to 2000, throughout the planning period. The costs shown under "1985 standards" are on the assumption that surface water disposal to 1983 standards would be utilized until 1990, at which time there would be an upgrading to interpreted 1985 standards using one of the three alternatives: swt, lp or li. (C+NS)-sw, which indicates surface water disposal with secondary treatment for the entire 20-year planning period under 1983 standards, shows a cost of $29.6 million for year-round P removal. Under 1985 standards, (C+NS)-sw/swt indicates ten years of operation to 1990 with secondary treatment followed by addition of tertiary treatment and ten years of tertiary treatment operation with a total cost of $47.9 million. For another example, (C+NS)-lp under 1983 standards indicates 20 years of operation with infiltration-percolation disposal, which would more than meet 1983 standards but may be desirable for other reasons, at a cost of $50.3 million. Under 1985 standards, (C+NS)-sw/lp indicated 10 years of operation with secondary treatment and surface water disposal, then upgrading to infiltration-percolation disposal in 1990 for operation in that mode thereafter for a total cost of $35.2 million. Note that the second cost is lower than the first, reflecting the early years operation at minimum standards. This is not an anomolous result but rather the result of two different bases for comparison. The basis under "1983 standards" shows what the cost comparison is if there is no need to upgrade before the end of the planning period. Under "1985 standards" is shown the consequences of assuming that the lowest cost method is used until 1990 at which time there is a compulsory upgrading. This distinction exists not only in Table 7-1 but in Tables 7-2 through 7-5, which are derived from Table 7-1.

Table 7-1 provides all of the necessary cost information which, when combined into regional plans, allows a ranking to be developed in order of increasing cost.

Table 7-2 ranks 57 system alternatives, which include Spokane Valley, for the condition of 1983 standards being in effect throughout the study period, 1980 to 2000, and for the seasonal phosphorus removal where disposal is to surface water.

Table 7-3 ranks 12 system alternatives which do not include Spokane Valley for the condition of 1983 standards in effect 1980 to 2000 and for seasonal phosphorus removal to surface water disposal.

TABLE 7-1

COSTS OF ALTERNATIVE PLAN ELEMENTS

	Costs in Millions of Dollars Present Worth of Capital Plus O&M						
	1983 Standards[1]				1985 Standards[2]		
Element	Seasonal P Removal	Year Around P Removal	P Removal Not Involved	Special Cost	Element	Cost	Special Cost
C-sw	20.0	23.4	--		C-sw/swt	39.9	
C-1p	--	--	42.1		C-sw/1p	28.6	
C-1i	--	--	88.9	54.6[5]	C-sw/1i	46.6	
(C+NS)-sw	25.9	29.6	--		(C+NS)-sw/swt	47.9	
(C+NS)-1p	--	--	50.3		(C+NS)-sw/1p	35.2	42.2[6]
(C+NS)-1i	--	--	102.9	65.7[5] 99.6[7]	(C+NS)-sw/1i	56.1	
(C+SV)-sw	41.4	45.5	--		(C+SV)-sw/swt	65.7	
(C+SV)-1p			66.6		(C+SV)-sw/1p	51.5	
(C+SV)-1i			125.1	83.0[5]	(C+SV)-sw/1i	77.3	
(C+NS+SV)-sw	53.8	58.3	--		(C+NS+SV)-sw/swt	80.2	
(C+NS+SV)-1p	--	--	79.8		(C+NS+SV)-sw/1p	64.8	
(C+NS+SV)-1i	--	--	143.9	100.8[5]	(C+NS+SV)-sw/1i	90.1	
NS-sw	11.3	11.8	--		NS-sw/swt	15.7	
NS-1p	--	--	16.0		NS-sw/1p	13.9	
NS-1i	--	--	15.3		NS-sw/1i	16.4	
SV-sw	16.0	17.2	--		SV-sw/swt	23.0	
SV-1p	--	--	31.6		SV-sw/1p	22.8	
SV-1i	--	--	29.3		SV-sw/1i	25.8	
(NS+SV)-sw	26.8	29.5	--		(NS+SV)-sw/swt	38.0	
(NS+SV)-1p	--	--	45.7		(NS+SV)-1p[4]	45.7	
(NS+SV)-1i	--	--	41.7		(NS+SV)-1i[4]	41.7	

[1]Costs in millions of dollars net present worth of capital and operation costs, 20-year period 1980 - 2000 with 1983 standards in effect throughout.

[2]Costs in millions of dollars net present worth of capital and operation costs, 20-year period 1980 - 2000 with 1983 standards in effect 1980 - 1990 and surface water disposal and interpreted 1985 standards in effect 1990 to 2000 with disposal as indicated.

[3]Legend for identification of alternative elements:

C = City of Spokane service area — sw/swt = sw to 1990, swt after 1990
NS = North Spokane service area — sw/1p = sw to 1990, 1p after 1990
SV = Spokane Valley service area — sw/1i = sw to 1990, 1i after 1990
sw = surface water disposal with secondary treatment
swt = surface water disposal with tertiary treatment
1p = land application to rapid percolation
1i = land application to irrigation

[4]In these cases, there is no surface water alternative for the 1980 - 1990 period that is cost-effectively convertible to 1p or 1i at 1990, hence, 1p and 1i respectively are used throughout the study period.

[5]Subalternative for summer seasonal disposal by land application to irrigation and winter season disposal to surface water. The basic alternative is for disposal of the entire years flow to irrigation. Subalternative is 1i-sw.

[6]Subalternative for pretreatment to include full nitrification-denitrification prior to percolation application to the downriver site. The basic alternative is for pretreatment to include secondary treatment without nitrification-denitrification.

[7]Subalternative for pretreatment before irrigation reduced from secondary to primary treatment (noting that capital costs for secondary are sunk).

TABLE 7-2

COST-EFFECTIVENESS RANKING - 1983 STANDARDS
ALL SYSTEMS, SEASONAL P REMOVAL

Rank	System	System Elements (1)	System Elements (2)	System Elements (3)	Total Cost $ Millions
1	2-1	(C+NS)sw		SV-sw	42.0
2	5-1	(NS+SV)sw	C-sw		46.8
3	1-1	C-sw	NS-sw	SV-sw	47.3
4	1-4	C-sw	NS-1i	SV-sw	51.3
5	1-7	C-sw	NS-1p	SV-sw	52.1
6	3-1	(C+SV)sw	NS-sw		52.6
7	4-1	(C+NS+SV)sw			53.8
8	2-2	(C+NS)sw		SV-1i	55.3
9	3-2	(C+SV)sw	NS-1i		56.7
10	3-3	(C+SV)sw	NS-1p		57.4
11	2-3	(C+NS)sw		SV-1p	57.6
12	1-2	C-sw	NS-sw	SV-1i	60.6
13	5-4	(NS+SV)1i	C-sw		61.8
14	1-3	C-sw	NS-sw	SV-1p	62.9
15	1-5	C-sw	NS-1i	SV-1i	64.7
16	1-8	C-sw	NS-1p	SV-1i	65.4
17	5-7	(NS+SV)1p	C-sw		65.7
18	2-7	(C+NS)1p		SV-sw	66.3
19	1-6	C-sw	NS-1i	SV-1p	66.9
20	1-9	C-sw	NS-1p	SV-1p	67.6
21	5-3	(NS+SV)sw	C-1p		68.9
22	1-19	C-1p	NS-sw	SV-sw	69.4
23	1-22	C-1p	NS-1i	SV-sw	73.5
24	1-25	C-1p	NS-1p	SV-sw	74.2
25	3-7	(C+SV)1p	NS-sw		77.9
26	2-8	(C+NS)1p		SV-1i	79.6
27	4-3	(C+NS+SV)1p			79.9
28	2-9	(C+SV)1p		SV-1p	81.92
29	3-8	(C+SV)1p	NS-1i		81.94
30	3-9	(C+SV)1p	NS-1p		82.6
31	1-20	C-1p	NS-sw	SV-1i	82.7
32	5-6	(NS+SV)1i	C-1p		83.9
33	1-21	C-1p	NS-sw	SV-1p	85.0
34	1-23	C-1p	NS-1i	SV-1i	86.8
35	1-26	C-1p	NS-1p	SV-1i	87.5
36	5-9	(NS+SV)1p	C-1p		87.8
37	1-24	C-1p	NS-1i	SV-1p	89.0
38	1-27	C-1p	NS-1p	SV-1p	89.7
39	5-2	(NS+SV)sw	C-1i		115.7
40	1-10	C-1i	NS-sw		116.2
41	2-4	(C+NS)1i		SV-sw	118.9
42	1-13	C-1i	NS-1i	SV-sw	120.2
43	1-16	C-1i	NS-1p	SV-sw	120.9
44	1-11	C-1i	NS-sw	SV-1i	129.5
45	5-5	(NS+SV)1i	C-1i		130.6
46	1-12	C-1i	NS-sw	SV-1p	131.8
47	2-5	(C+NS)1i		SV-1i	132.2
48	1-14	C-1i	NS-1i	SV-1i	133.5
49	1-17	C-1i	NS-1p	SV-1i	134.2
50	2-6	(C+NS)1i		SV-1p	134.5
51	5-8	(NS+SV)1p	C-1i		134.6
52	1-15	C-1i	NS-1i	SV-1p	135.8
53	3-4	(C+SV)1i	NS-sw		136.3
54	1-18	C-1i	NS-1p	SV-1p	136.5
55	3-5	(C+SV)1i	NS-1i		140.4
56	3-6	(C+SV)1i	NS-1p		141.1
57	4-2	(C+NS+SV)1i			143.9

TABLE 7-3

COST-EFFECTIVENESS RANKING - 1983 STANDARDS
EXCLUSIVE OF SPOKANE VALLEY - SEASONAL P REMOVAL

Rank	System	System Elements (1)	(2)	(3)	Total Cost Million Dollars
1	6-10	(C+NS)-sw			25.9
2	6-1	C-sw	NS-sw		31.2
3	6-2	C-sw	NS-1i		35.3
4	6-3	C-sw	NS-1p		36.0
5	6-12	(C+NS)-1p			50.3
6	6-7	C-1p	NS-sw		53.4
7	6-8	C-1p	NS-1i		57.4
8	6-9	C-1p	NS-1p		58.1
9	6-4	C-1i	NS-sw		100.2
10	6-11	(C+NS)-1i			102.9
11	6-5	C-1i	NS-1i		104.2
12	6-6	C-1i	NS-1p		104.9

Tables are not included herein for ranking with year-round phosphorus removal since it is found that the ranking is not significantly different than for seasonal removal.

Table 7-4 ranks 57 alternative systems including Spokane Valley, for the condition of 1983 standards and surface water disposal in force 1980 to 1990 and with interpreted 1985 standards in force 1990 to 2000 applying alternative disposal systems.

Table 7-5 ranks 12 alternative systems excluding Spokane Valley for same conditions as Table 7-4.

For 1983 standards the following conclusions are drawn regarding cost-effectiveness of alternative plans:

1. Surface water disposal is the least costly method for all elements. For all City combined elements, infiltration-percolation ranks second with costs of the order 50 to 100 percent higher than surface water disposal. Irrigation disposal is most costly with cost approximately 100 to 300 percent higher than surface water disposal. For elements where the City is not included irrigation is slightly lower in cost than percolation.

TABLE 7-4

COST-EFFECTIVENESS RANKING - 1985 STANDARDS
ALL SYSTEMS

Rank	System	System Elements (1)	(2)	(3)	Total Cost Million Dollars
1	2-9	(C+NS)-sw/1p		SV-sw/1p	58.0
2	2-7	(C+NS)-sw/1p		SV-sw/swt	58.2
3	2-8	(C+NS)-sw/1p		SV-sw/1i	61.0
4	4-3	(C+NS+SV)-sw/1p			64.8
5	1-27	C-sw/1p	NS-sw/1p	SV-sw/1p	65.3
6	3-9	(C+SV)-sw/1p	NS-sw/1p		65.4
7	1-25	C-sw/1p	NS-sw/1p	SV-sw/swt	65.5
8	5-3	(NS+SV)-sw/swt	C-sw/1p		66.6
9	1-21	C-sw/1p	NS-sw/swt	SV-sw/1p	67.1
10	3-7	(C+SV)-sw/1p	NS-sw/swt		67.2
11	1-19	C-sw/1p	NS-sw/swt	SV-sw/swt	67.3
12	1-24	C-sw/1p	NS-sw/1i	SV-sw/1p	67.8
13	3-8	(C+SV)-sw/1p	NS-sw/1i		67.9
14	1-22	C-sw/1p	NS-sw/1i	SV-sw/swt	68.0
15	1-26	C-sw/1p	NS-sw/1p	SV-sw/1i	68.3
16	1-20	C-sw/1p	NS-sw/swt	SV-sw/1i	70.1
17	5-6	(NS+SV)-1i[1]	C-sw/1p		70.3
18	2-3	(C+NS)-sw/swt		SV-sw/1p	70.7
19	1-23	C-sw/1p	NS-sw/1i	SV-sw/1p	70.8
20	2-1	(C+NS)-sw/swt		SV-sw/swt	70.9
21	2-2	(C+NS)-sw/swt		SV-sw/1i	73.7
22	5-9	(NS+SV)-1p[1]	C-sw/1p		74.3
23	1-9	C-sw/swt	NS-sw/1p	SV-sw/1p	76.6
24	1-7	C-sw/swt	NS-sw/1p	SV-sw/swt	76.8
25	5-1	(NS+SV)-sw/swt	C-sw/swt		77.9
26	1-3	C-sw/swt	NS-sw/swt	SV-sw/1p	78.4
27	1-1	C-sw/swt	NS-sw/swt	SV-sw/swt	78.6
28	2-6	(C+NS)-sw/1i		SV-sw/1p	78.9
29	1-6	C-sw/swt	NS-sw/1i	SV-sw/1p	79.10
30	2-4	(C+NS)-sw/1i		SV-sw/swt	79.11
31	1-4	C-sw/swt	NS-sw/1i	SV-sw/swt	79.3
32	1-8	C-sw/swt	NS-sw/1p	SV-sw/1i	79.63
33	3-3	(C+SV)-sw/swt	NS-sw/1p		79.66
34	4-1	(C+NS+SV)-sw/swt			80.2
35	1-2	C-sw/swt	NS-sw/swt	SV-sw/1i	81.44
36	3-1	(C+SV)-sw/swt	NS-sw/swt		81.47
37	5-4	(NS+SV)-1i[1]	C-sw/swt		81.6
38	2-5	(C+NS)-sw/1i		SV-sw/1i	81.9
39	1-5	C-sw/swt	NS-sw/1i	SV-sw/1i	82.1
40	3-2	(C+SV)-sw/swt	NS-sw/1i		82.1
41	1-18	C-sw/1i	NS-sw/1p	SV-sw/1p	83.3
42	1-16	C-sw/1i	NS-sw/1p	SV-sw/swt	83.5
43	5-2	(NS+SV)-sw/swt	C-sw/1i		84.6
44	1-12	C-sw/1i	NS-sw/swt	SV-sw/1p	85.1
45	1-10	C-sw/1i	NS-sw/swt	SV-sw/swt	85.3
46	5-7	(NS+SV)-1p[1]	C-sw/swt		85.6
47	1-15	C-sw/1i	NS-sw/1i	SV-sw/1p	85.8
48	1-13	C-sw/1i	NS-sw/1i	SV-sw/swt	86.0
49	1-17	C-sw/1i	NS-sw/1p	SV-sw/1i	86.3
50	1-11	C-sw/1i	NS-sw/swt	SV-sw/1i	88.1
51	5-5	(NS+SV)-1i[1]	C-sw/1i		88.3
52	1-14	C-sw/1i	NS-sw/1i	SV-sw/1i	88.8
53	4-2	(C+NS+SV)-sw/1i			90.1
54	3-6	(C+SV)-sw/1i	NS-sw/1p		91.2
55	5-8	(NS+SV)-1p[1]	C-sw/1i		92.3
56	3-4	(C+SV)-sw/1i	NS-sw/swt		93.0
57	3-5	(C+SV)-sw/1i	NS-sw/1i		93.7

[1]See note[4] on Table 7-1.

TABLE 7-5

COST-EFFECTIVENESS RANKING - 1985+ STANDARDS
EXCLUDING SPOKANE VALLEY

Rank	System	System Elements (1)	(2)	(3)	Total Cost Million Dollars
1	6-12	(C+NS)sw/1p			35.2
2	6-9	C-sw/1p	NS-sw/1p		42.5
3	6-7	C-sw/1p	NS-sw/swt		44.3
4	6-8	C-sw/1p	NS-sw/1i		45.0
5	6-10	(C+NS)sw/swt			47.9
6	6-3	C-sw/swt	NS-sw/1p		53.8
7	6-1	C-sw/swt	NS-sw/swt		55.6
8	6-11	(C+NS)sw/1i			56.1
9	6-2	C-sw/swt	NS-sw/1i		56.3
10	6-6	C-sw/1i	NS-sw/1p		60.5
11	6-4	C-sw/1i	NS-sw/swt		62.3
12	6-5	C-sw/1i	NS-sw/1i		63.0

2. There is a distinct cost advantage in combining NS with the City regardless of the ultimate kind of disposal.

3. There is no cost advantage in combining City and SV regardless of the ultimate kind of disposal.

4. The lowest cost system is one combining the City and NS to surface water disposal, with SV separate to surface water disposal.

5. If SV combinations are excluded from the ranking, the City combined with NS to surface water disposal is still the lowest cost system.

If the subalternative for summer irrigation with winter surface water disposal is substituted for irrigation disposal year-round using seasonal storage, the ranking of irrigation disposal relative to percolation and surface water is not changed. The gap is almost closed relative to percolation but remains more than 50 percent more costly than year-round surface water disposal. The major defect of this system is that it does not lend itself to economical upgrading to 1985 standards.

The subalternative for the substitution of primary for secondary pretreatment before irrigation application is found to make no significant difference to City combined alternatives, as might be expected since the capital cost component is a sunk cost. Even if the secondary component were not a sunk cost, and an additional $8 million were deducted, the ranking would remain 80 percent higher than infiltration-percolation.

For the conditions where interpreted 1985 standards are imposed in 1990 the cost-effective conclusions are as follows:

1. Conversion to percolation disposal is the most cost-effective method of achieving interpreted 1985 standards for all elements except NS and SV combined.

2. From a regional standpoint, the three most cost-effective systems involve the same service area combinations as the lowest cost system under 1983 standards, namely City and NS combined, with SV separate.

3. The three most cost-effective systems all involve conversion to infiltration-percolation by the City-NS element with the relative ranking depending only on the disposal method for SV.

4. The lowest cost system uses conversion to infiltration-percolation for both elements, City-NS combined, with SV separate.

5. The lowest cost system with SV excluded is the same City-NS combination upgraded to infiltration-percolation.

The basic costing for all City involved rapid percolation (lp) alternatives assumes that nitrification-denitrificaiton is not a prerequisite for disposal at the downriver site. There is a possibility that this may not be acceptable. Therefore, a special alternative costing is made to determine if the addition of nitrification-denitrification would affect the ranking. The result is shown in Table 7-1. Note (6) special cost for the element (C+NS)-sw/1p. The resultant increase in cost is not sufficient to change the ranking of lp alternatives relative to sw or li.

Conclusions Based on Cost-Effective Analysis

The lowest cost system for as long as 1983 standards are in force is surface water disposal with the City and North Spokane combined to the existing City STP and with Spokane Valley being treated and disposed separately. This result holds whether the requirement for phosphorus removal is seasonal or year-round. This alternative is likewise compatible with the most cost-effective systems when and if more stringent standards are imposed and is compatible with the need to be flexible with regard to whether Spokane Valley acts to construct community sewerage or not.

If more stringent surface water disposal criteria are imposed, surface water disposal is no longer the most cost-effective alternative. The most cost-effective alternative for City combinations is land application to percolation. All of the major facilities previously needed for surface water disposal are still required and the facilities for land application are all additive. Continuation of surface water disposal by increasing the level of treatment to satisfy interpreted 1985 standards is more costly than going to percolation disposal, even if complete nitrification and denitrification are made a pretreatment requirement at the downriver site. Land application by irrigation with the total annual flow is more costly than either advanced treatment for surface water disposal or percolation with or without nitrification-denitrification.

Therefore, from a cost standpoint alone, the selection of an initial system for surface water disposal, combining the City and North Spokane to the existing City plant, would provide a flexible basis for either continuation or conversion to land application by percolation at a later date. The size of the percolation site required and the limited availability of suitable land within economical conveyance distance indicates the need to acquire the percolation site now or perserve its availability through zoning.

To go to other than surface water for City involved alternatives prior to a requirement to meet disposal criteria more strict than 1983 involves significantly greater costs which must be weighed against any net non-monetary advantages. The added cost to go to land application by percolation is of the order $20 million and to go to land application by irrigation is of the order $70 million. There would be a very high price tag on any such non-monetary advantages.

For Spokane Valley, the cost-effective choice is surface water disposal until such time as criteria more stringent than 1983 are imposed. The advantage over land application is large, being of the order of $12 to $14 million. With the imposition of interpreted 1983 standards, the cost-favored alternative for Spokane Valley becomes rapid percolation despite the criteria for full nitrification-denitrification used in this case. This lends itself to a stepwise approach as in the case of City alternatives by utilizing surface water disposal as the initial phase and in 1990 increasing treatment to include nitrification-denitrification and providing for land application to rapid percolation. Irrigation remains more costly either initially using lagoon treatment or stepwise using concentrated site treatment for surface water disposal and converting to irrigaitcn at 1990.

The "no action" alternative for Spokane Valley, which means continuing with individual on-site disposal, is the lowest cost since the existing individual facilities are a sunk cost and the forecast growth percentage-wise is relatively small. A cost is not developed for this alternative.

Selection of Candidates for Second Step Evaluation

The following goals are selected as embodying the overall primary social, economic and environmental objectives which should be represented by candidate plans. At least one alternative plan that appears strongly responsive to each of these goals and is cost-effective for its category is selected for further detailed analysis:

1. Minimize regional cost.

2. Maximize protection of surface waters from pollution.

3. Maximize protection of ground waters from pollution.

4. Maximize water reclamation and reuse.

5. Minimize disruption of natural habitat or enhance natural habitat restoration.

6. Minimize displacement of people from their homes or employment.

7. Minimize disruption of land use patterns.

8. Minimize energy consumption.

9. Possess maximum potential for achieving the 1985 goal of "no pollution."

A thorough canvass of the system alternatives in cost-effectiveness rank ordered against the goals listed above results in the selection of alternatives which appear to most effectively meet one or more of these goals and also includes at least one alternative that is most qualified to meet each goal.

The selected candidate regional plans for second step evaluation are as follows, summarized in Table 7-6, and shown in plans in Figures 7-1 through 7-8.

Plan A — The City and North Spokane are combined to form a subsystem using the upgraded City STP with surface water disposal. The Spokane Valley is provided separate treatment at a valley location with surface water disposal. This selection is made for its lowest cost position and to represent traditional surface water disposal.

TABLE 7-6

SUMMARY OF SELECTED CANDIDATE PLANS
FOR STEP 2 EVALUATION

Plan Identifier	Symbol	Description	Basis for Selection
A	(C+NS)-sw, SV-sw	Surface water disposal, City and North Spokane combined, Spokane Valley separate.	Selected for its least cost position and as representative of traditional surface water disposal.
B	C-sw, NS-li, SV-sw	Separate disposal for all service areas, City to surface water, North Spokane to irrigation, Spokane Valley to surface water.	Selected as an example of an institutionally independent system wherein each service area provides its own facilities plus including the application of irrigation disposal to the NS element where the cost penalty for irrigation is lowest.
C	(C+NS+SV)-sw	All service areas combined to surface water disposal.	Selected because it is the lowest cost representative of a single system regional plan.
D	(C+NS)sw/lp, SV-sw/lp	City and North Spokane combined to initial surface water disposal converted to rapid percolation at 1990; Spokane Valley separate to initial surface water disposal converted to rapid percolation in 1990.	Selected because it is the lowest cost method of upgrading to 1985 standards of the plan which is lowest cost under 1983 standards, Plan A. *This system also* provides representation of the infiltration-percolation disposal technique.
E	(C+NS)-li-sw, SV-li	City and North Spokane combined to summer season irrigation and winter surface water disposal; Spokane Valley separate to irrigation.	Selected as the lowest cost representative of land application for the entire service area. It should be noted that this plan also represents the system of seasonal land application with surface water disposal as the off season method.
F	(C+NS)-li, SV-li	City and North Spokane combined to irrigation; Spokane Valley separate to irrigation.	Selected to represent total land application of all wastewater flows from all service areas. This system represents complete reclamation for irrigation use and full time compliance with interpreted 1985 standards.
G	(NS+SV)li, C-sw/lp	North Spokane and Spokane Valley combined to irrigation, City separate, initially to surface water phased to rapid percolation in 1990.	Selected to represent those systems which combine County area, with the City separate. A system with land application from the start for NS+SV is selected and combined with a City system starting with surface disposal and then being upgraded to interpreted 1985 standards. This system is also selected for its better cost position relative to Plan D than offered by Plans E or F.
H	C-sw, NS-sw, SV-sw	Separate disposal for all service areas to surface water.	Selected to represent the condition described for North Spokane in the present County Adopted Plan.
I	No Action	City to surface water disposal utilizing committed upgraded STP; North Spokane and Spokane Valley to continue with individual and small group on site disposal systems.	

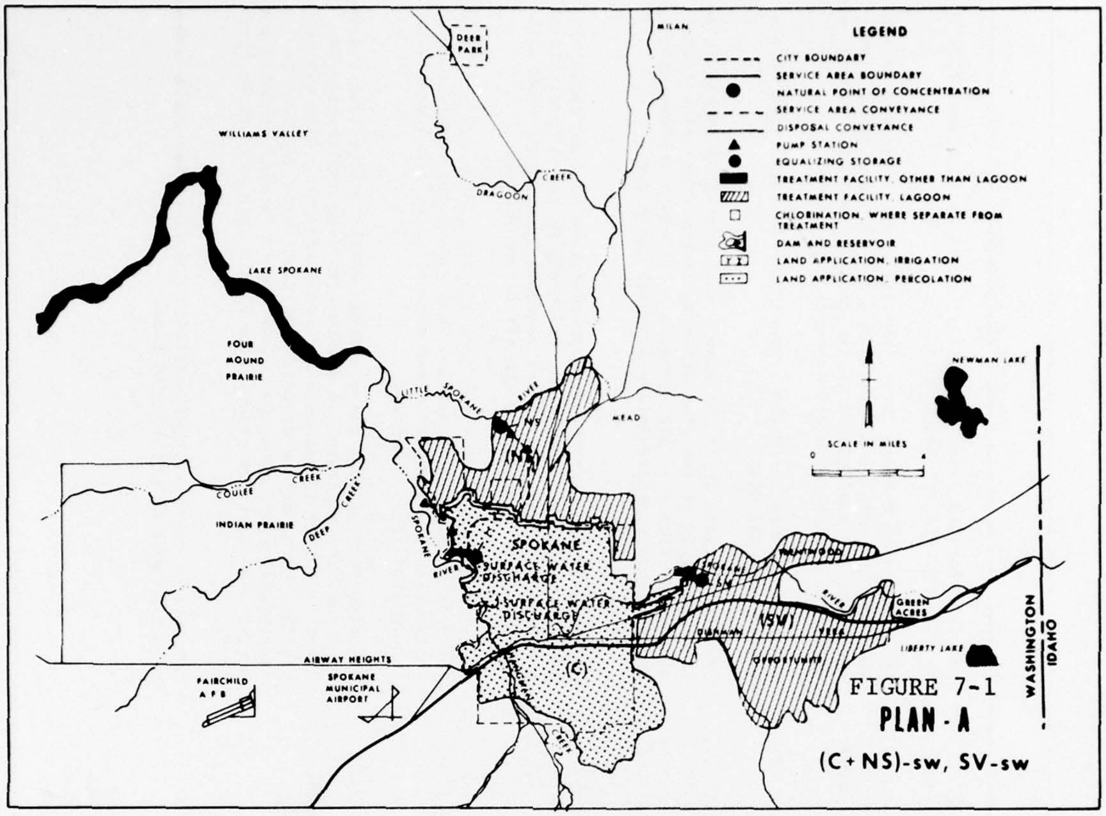


FIGURE 7-1

PLAN - A

(C+NS)-sw, SV-sw

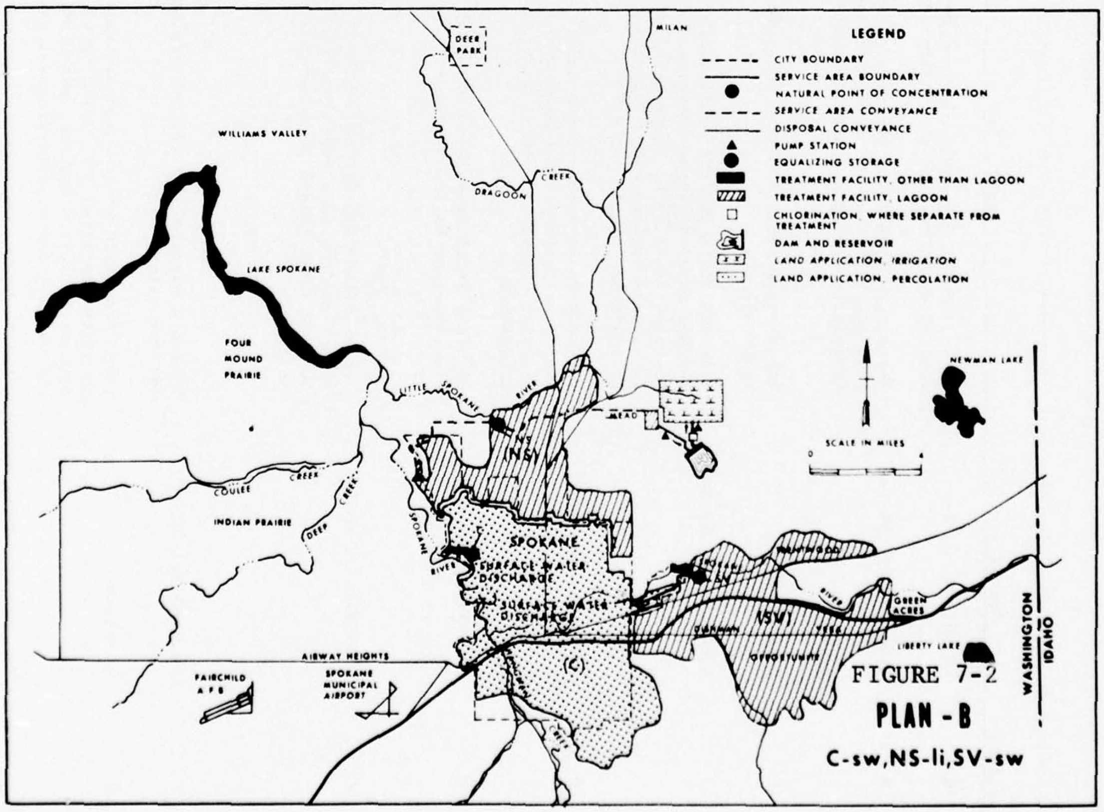


FIGURE 7-2

PLAN - B

C-sw,NS-li,SV-sw

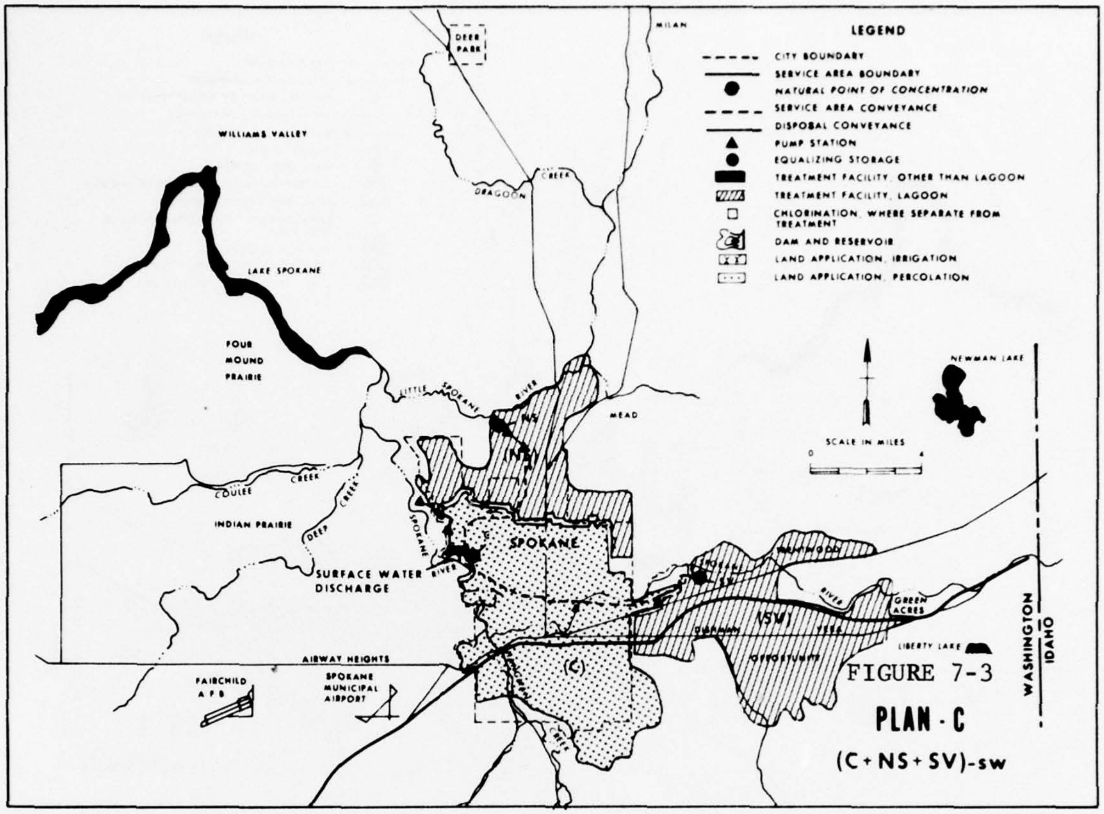


FIGURE 7-3

PLAN - C

(C+NS+SV)-sw

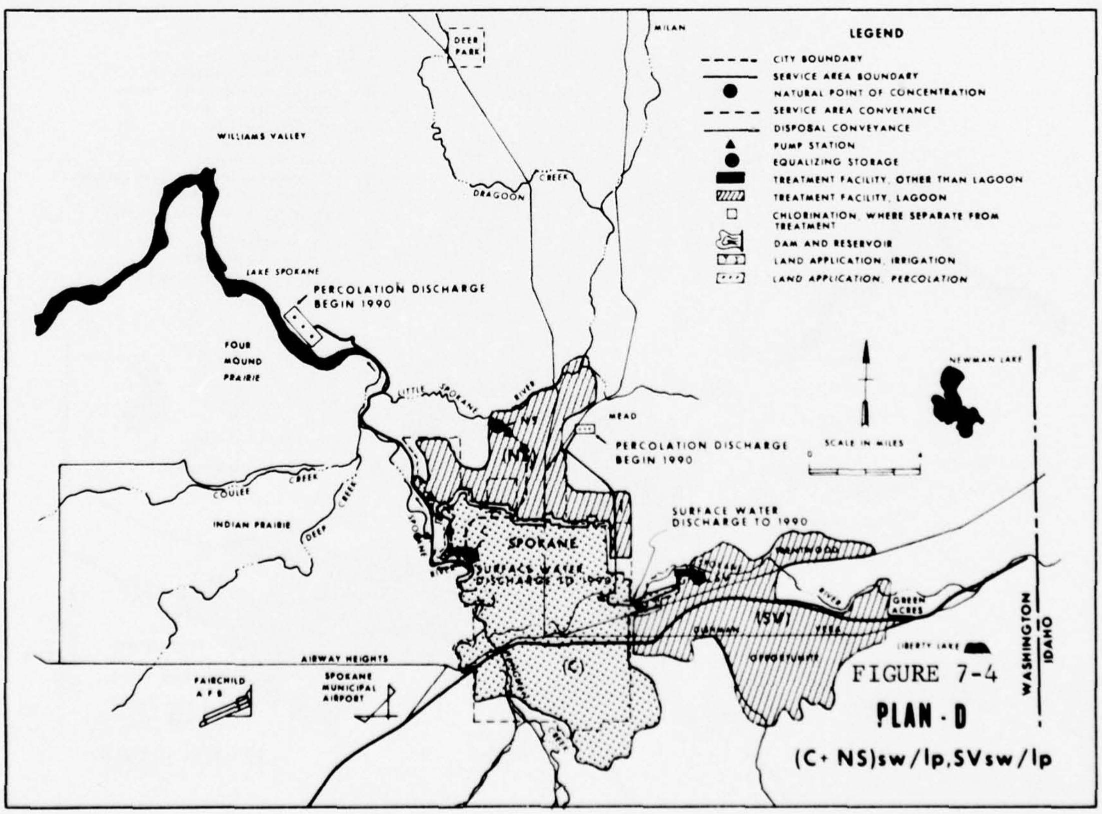


FIGURE 7-4

PLAN - D

(C+NS)sw/lp,SVsw/lp

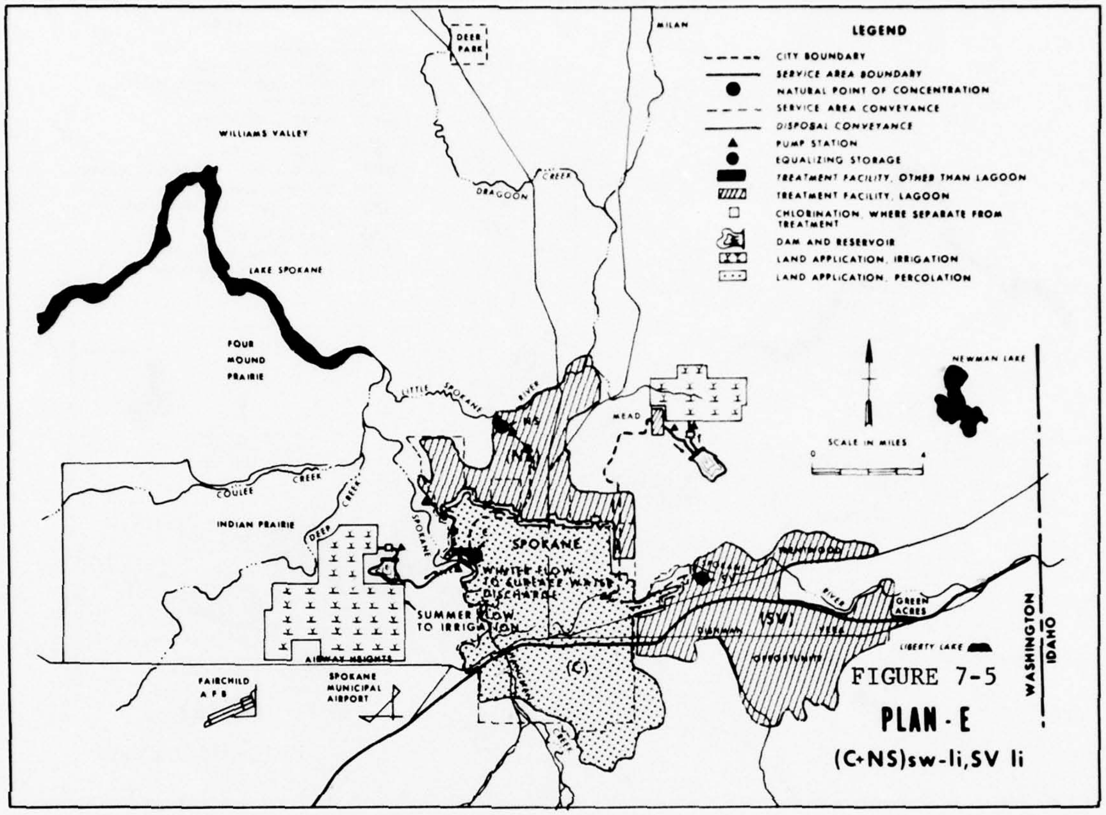


FIGURE 7-5

PLAN - E

(C+NS)sw-li,SV li

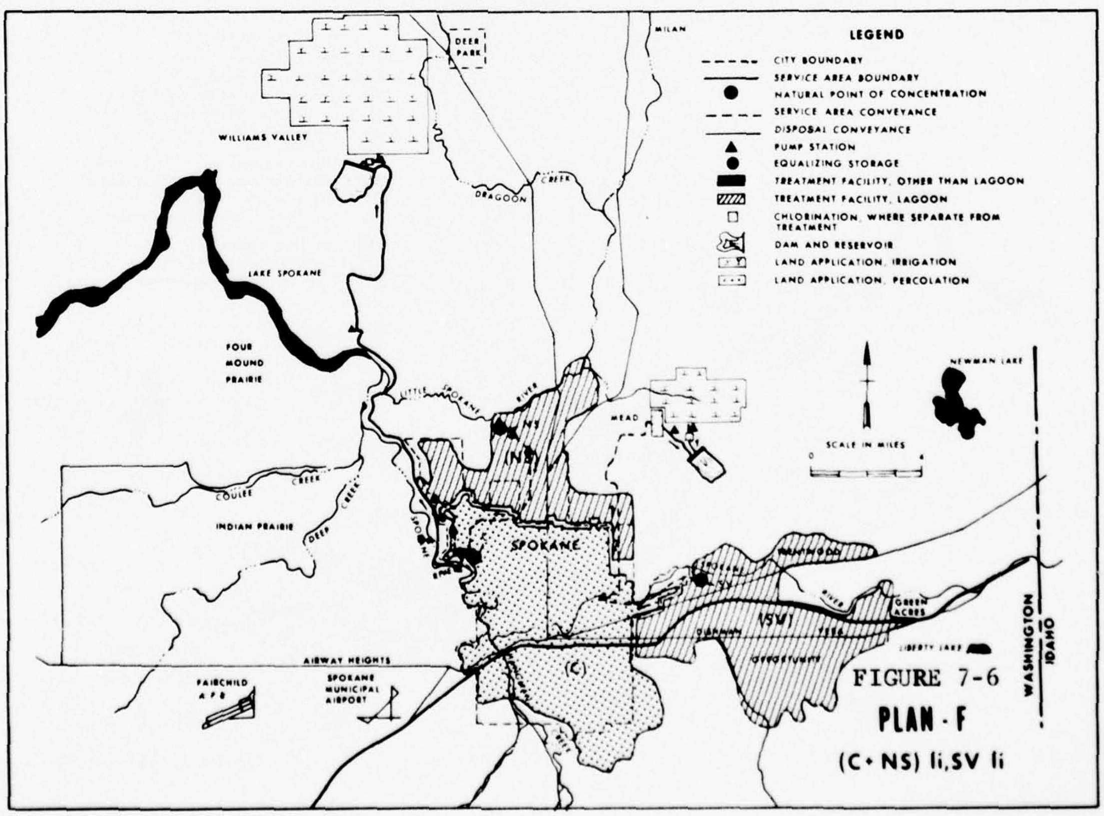


FIGURE 7-6

PLAN - F

(C+NS) li,SV li

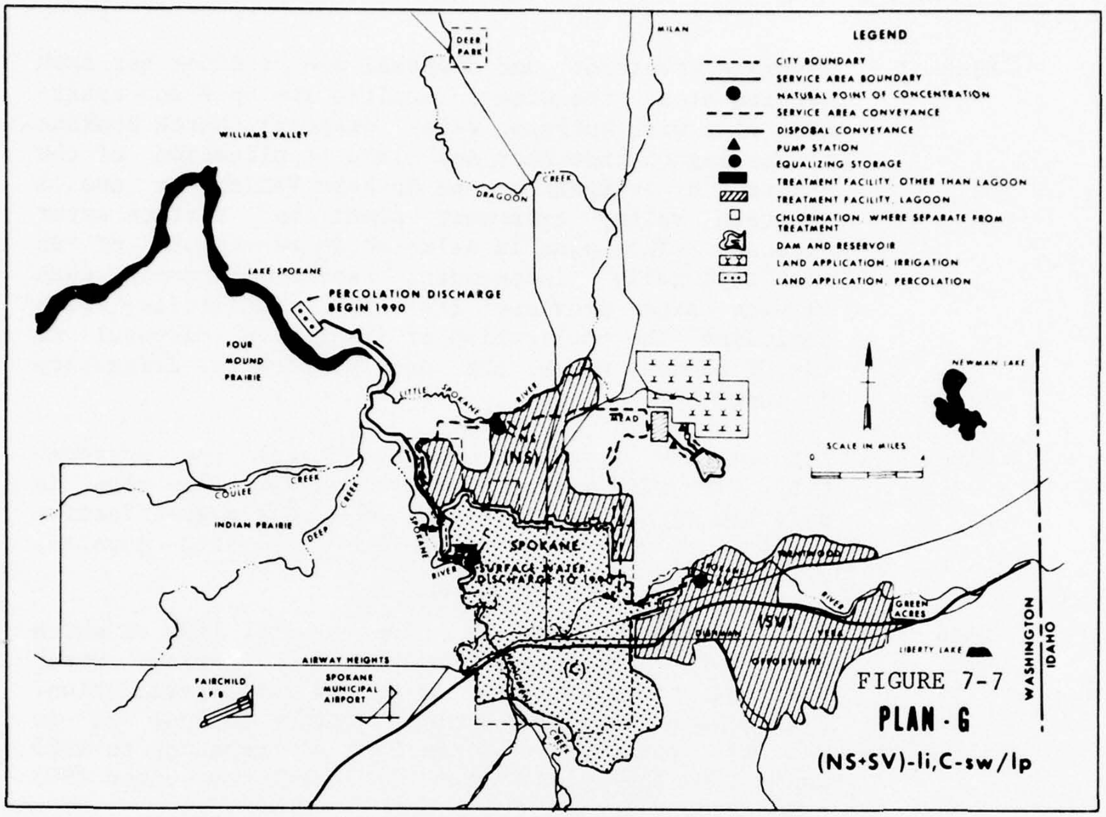


FIGURE 7-7

PLAN - G

(NS+SV)-li,C-sw/lp

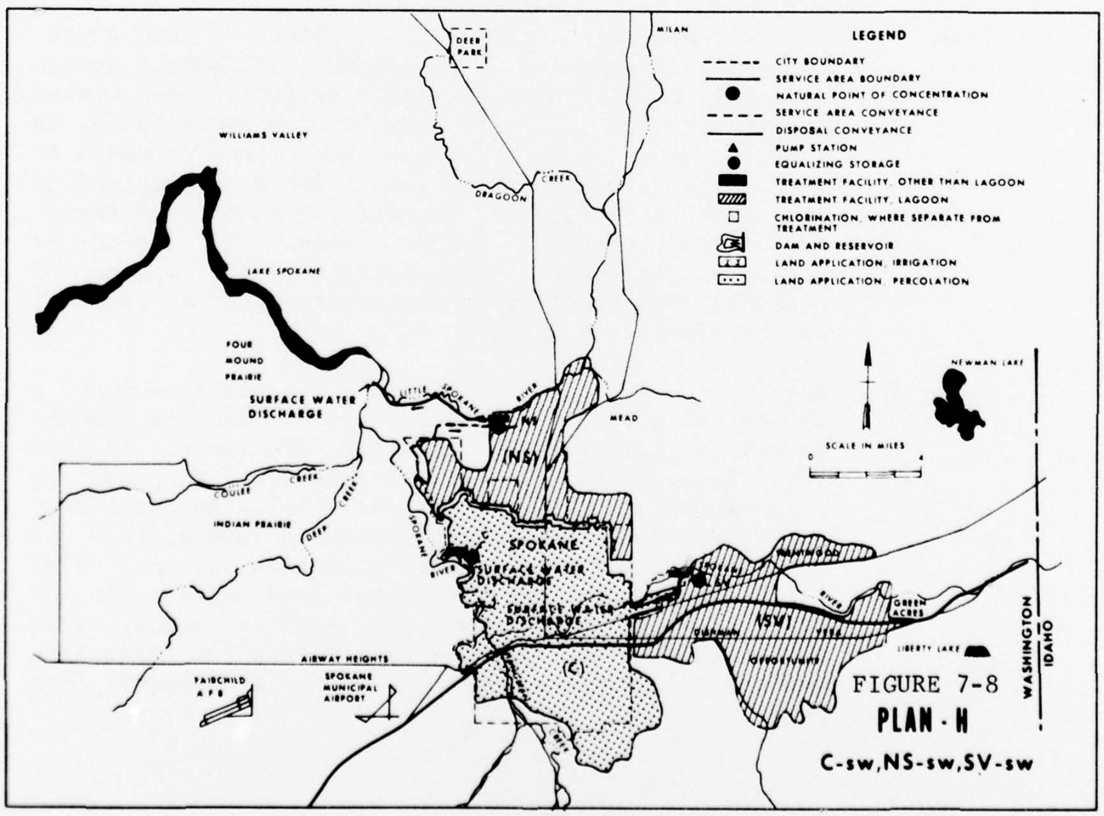


FIGURE 7-8

PLAN - H

C-sw,NS-sw,SV-sw

Plan B — Separate treatment and disposal are provided for each service area: the City to utilize its upgraded treatment plan with surface water disposal; North Spokane to use lagoon treatment and land application of the effluent by irrigation; and Spokane Valley to use a separate valley treatment plant and surface water disposal. This plan is selected as an example of an institutionally independent system wherein each service area provides its own facilities plus including the application of irrigation disposal to the NS element where the cost penalty for irrigation is lowest.

Plan C — All service areas are combined to use the upgraded City STP with surface water disposal. This plan is selected as a representative of a most cost-effective regional plan using a single integrated physical system.

Plan D — This plan is the same as Plan A until 1990 at which time both systems are converted from surface water disposal to land application by rapid percolation. Plan D is selected for future adoption because it is the most cost-effective method of upgrading to 1985 goals of the plan which is lowest cost under 1983 standards, Plan A.

Plan E — The City and North Spokane are combined to form a system using the upgraded City STP but with summer season disposal to land application by irrigation and winter season disposal to surface water. Spokane Valley is provided separate treatment and year-round disposal to land application by irrigation. Plan E is selected as the most cost-effective representative of land application for the entire service area. It should be noted that this plan also represents the system of seasonal land application with surface water disposal as the off season method.

Plan F — Again, the City and North Spokane are combined into a system using the upgraded City STP and the Spokane Valley is provided with separate treatment. In this case both subsystems utilize year-round disposal to land application by irrigation. (All plans utilizing year-round disposal to irrigation include storage for the effluent during the non-irrigation season.) Plan F is selected to represent total land application of all wastewater flows from all service areas. This system represents complete reclamation for irrigation use and full-time compliance with interpreted 1985 goals.

TABLE 7-7

SUMMARY RANKING OF CANDIDATE PLANS
BY CHARACTERISTICS AND CONCERNS

CHARACTERISTICS AND CONCERNS	Ranking of Candidate Plans** A	B	C	D	E	F	G	H
1. COST-EFFECTIVENESS								
a. Present worth of the sum of capital and operation and maintenance costs	42.0	51.3	53.8	58.0	95.1	132.2	70.4	47.3
b. Is most cost effective	1	3	4	5	7	8	6	2
2. DIRECT ECONOMIC CONCERNS								
a. Has lowest requirement for capital	1	3	4	5	7	8	6	2
b. Has lowest annual O&M cost	5*	4*	6*	7*	2	1	3	8*
c. Causes minimum loss of employment and real income due to displacement	1*	3	1*	2	5	6	4	1*
d. Causes minimum loss of tax revenue due to displacement	2	5	1	4	7	8	6	3
3. INDIRECT ECONOMIC CONCERNS								
a. Has maximum favorable impact on attractiveness to business and rise in level of economic activity	1*	1*	1*	1*	2	3	1*	1*
4. TRANSIENT ECONOMIC CONCERNS								
a. Has maximum potential for local employment increase during construction	7	5	6	4	2	1	3	8
b. Has maximum potential for increase in local manufacture and supply activity during construction	7	6	5	4	2	1	3	8
c. Will cause minimum disruption of circulation and business activity during construction	2	3	5	4*	4*	4*	4*	1
5. SOCIAL CONCERNS FOR THE COMMUNITY								
a. Has most favorable impact on health, welfare and safety	2*	2*	3*	1*	3*	1*	3*	3*
b. Causes the least disruption to existing community living patterns	1*	3	1*	2	5	6	4	1*
c. Has the most beneficial impact on availability of recreation	7	6	5	3	2	1	4	8
d. Introduces the least constraints to land use and land use planning	1*	3	1*	2	5	6	4	1*
6. SOCIAL CONCERNS FOR THE INDIVIDUAL								
a. Causes the least dislocation of individuals from their homes, employment and general pattern of cultural activity	1*	3	1*	2	5	6	4	1*
7. CONCERNS FOR GROUNDWATER								
a. Provides maximum protection of groundwater quality	4*	5	1	7	6	2	3	4*

CHARACTERISTICS AND CONCERNS	Ranking of Candidate Plans** A	B	C	D	E	F	G	H
8. CONCERNS FOR SURFACE WATER								
a. Provides maximum protection or enhancement of surface water quality for all concerns	6	6	5	4	2	1	3	7
9. CONCERNS FOR LAND USE								
a. Preserves or increases land available for wildlife habitat, natural vegetation and open space	2	4	1	7	5	6	8	3
b. Preserves or enhances the aesthetic value of the landscape	2	4	1	7	5	6	8	3
c. Creates least interference with other beneficial uses of land	2	4	1	8	6	5	7	3
10. CONCERNS FOR AIR QUALITY								
a. Provides maximum protection of public health aspects of air quality	1*	2	1*	1*	4	4	3	1*
b. Provides minimum potential for deterioration of aesthetic quality of air	2	4	1	5	8	6	7	3
11. CONCERNS FOR ENERGY AND RESOURCES								
a. Requires minimum input of 10^6 kwh electrical energy	407 1	438 2	489 4	556 5	921 7	1231 8	620 6	441 3
b. Requires minimum input of chemicals	4*	3	4*	5	1*	1*	2	4*
c. Provides the maximum opportunity for energy and resource recovery	1*	1*	1*	2*	2*	1*	2*	1*
d. Has lowest net energy requirement considering recovery	1	2*	3	4	6	7	5	2*
12. PERFORMANCE EVALUATION								
a. Provides best technical performance in wastewater renovation	7	6	5	3	4	1	2	8
b. Provides highest degree of reliability	7	6	5	3	4	1	2	8
13. FLEXIBILITY								
a. Has maximum flexibility to meet unanticipated changes in growth	3	2	7	4	6	8	5	1
b. Has maximum flexibility in adapting to changes in disposal criteria	6	3*	5	3*	4	1	2	7
c. Has maximum flexibility to incorporate changes in technology of wastewater treatment	3*	4	5	3*	2*	2*	1	6

*Indicates small or insignificant difference in ranking.
**Rankings are relative, in order, from 1, highest ranked, to 8, lowest ranked.

Plan G — This plan combines North Spokane and Spokane Valley into a unified subsystem with lagoon treatment and year-round disposal to land application by irrigation. The City remains separately served by its upgraded treatment plant, utilizing surface water disposal to 1990 at which time disposal is converted to year-round land application by rapid percolation. Plan G is selected to represent those systems which combine County area, with the City separate. A system with land application from the start for North Spokane plus Spokane Valley is selected and combined with a City system starting with surface disposal and then being upgrade to interpreted 1985 goals. This system is also selected for its better cost position relative to Plan D than offered by Plans E or F.

Plan H — This plan provides separate treatment and disposal for all three service areas. All three, including North Spokane, are provided with surface water disposal. This plan is selected to represent the same condition for North Spokane as in the present County Adopted Plan.

Plan I — This is the "no action" plan and provides for the City to use its own STP for surface water disposal, North Spokane to continue with a mixture of on-site disposal and interim lagoon facilities and for Spokane Valley to continue with on-site disposal.

Basis for Second Step Evaluation

The basis for the second evaluation step being applied to the list of candidate plans above is a selected list of concerns for economic, social and environmental impact. These concerns are summarized in Table 7-7 together with the ordered ranking of alternative plans. Obviously, all the concerns listed in Table 7-7 do not have the same weight in the evaluation process. Also, there is no absolute basis for establishing weighting. Reliance must be placed on judgment. In order to establish a system of evaluation which minimized the risk of bias in the selection of weighting factors, the list of concerns are subdivided into two categories of importance, each of which are processed with a range of weighting factors. The results of the evaluations of the two categories are then recombined, again with a range of weighting factors.

Table 7-8 shows the concerns designated Group 1 which are judged to have the greatest importance and significance to the selection process. Also shown in Table 7-8 are the four weighting systems used to bracket the extremes of probable bias ranging from heavily weighted to cost to heavily weighted to water quality.

TABLE 7-8

GROUP 1 CONCERNS FOR
ECONOMIC, SOCIAL AND ENVIRONMENTAL EVALUATION

Concern	Range of Weightings			
	Heavily Weighted To Cost Weight	Moderately Weighted To Cost Weight	Moderately Weighted To Water Quality Weight	Heavily Weighted To Water Quality Weight
1a Has lowest total cost for the planning period	65	50	30	20
2d Causes minimum loss of tax revenue	7	10	6	5
5b Causes least disruption to community living patterns	3	3	5	5
7a Provides maximum protection of groundwater quality	10	15	20	25
8a Provides maximum protection of surface water quality	10	15	20	25
11d Has lowest net energy requirement	3	3	7	7
12a Provides best technical performance of wastewater renovation	1	2	7	10
13a Has maximum flexibility for unanticipated growth	1	2	5	3
TOTALS	100	100	100	100

Note that concern for fish habitat is a major item in the application of ranking under concerns for surface water quality. For example, a surface water disposal, regardless of the quality of the effluent, is recognized as a potential negative impact. And, for the same quality effluent, multiple discharges are ranked lower than single because each discharge opens another reach of stream to potential negative impact exposure.

In a similar way, wildlife habitat is a major element under concerns for land use. Conversion of heterogeneous farming area to uniform single crop operation under irrigation alternatives is recognized as a negative impact although the change may favor one or several species. Reduction of variety and mixed habitat is regarded as a loss of enrichment.

Table 7-9 shows the concerns designated Group 2 which are judged to be of lesser importance or to have less significance to the selection process. Also shown in Table 7-9 are the three weighting systems ranging in bias from heavily weighted to economic concerns to heavily weighed to social and environmental concerns. The results of evaluation of all alternatives against both groups of concerns for all weighting systems are summarized in Table 7-10. As a final step, the Group 1 and Group 2 evaluations are combined with two ranges of weighting, one giving three times and one giving nine times the weight to Group 1 as compared with Group 2. Table 7-10 divides the candidate plans into two categories, those that meet only 1983 standards throughout the planning period and those that would either meet interpreted 1985 standards throughout, as Plan F, or those that would meet these standards after 1990, as Plan D and G.

TABLE 7-9

GROUP 2 CONCERNS FOR
ECONOMIC, SOCIAL AND ENVIRONMENTAL EVALUATION

Concern		Range of Weightings		
		Weighted Toward Economic Values Weight	Balanced Weighting Weight	Weighted Toward Environmental and Social Concerns Weight
2c	Causes minimum loss of employment and real income	10	6	3
3a	Has maximum favorable impact on business and economic activity	10	5	2
4a	Has maximum potential for local employment during construction	10	5	1
4b	Has maximum potential for local manufacturing and supply during construction	10	5	1
4c	Will cause minimum disruption during construction	10	7	7
5a	Has most favorable impact on health, safety and welfare	4	5	8
5c	Has most beneficial impact on availability of recreation	2	5	8
5d	Introduce least constraints to land use and planning	5	5	6
6a	Causes least dislocation of individuals	2	5	7
9a	Preserves or increases land available for habitat or open space	2	5	9
9b	Preserves or enhances aesthetic value of landscape	2	5	7
9c	Creates least interference with other beneficial use of land	5	5	4
10a	Provides maximum protection of health aspects of air quality	2	7	8
10b	Provides minimum potential for deterioration of aesthetic quality of air	1	5	7
11b	Require minimum input of chemicals	10	7	2
12b	Provides highest degree of reliability	7	8	9
13b	Has maximum flexibility to meet changes in disposal criteria	4	5	6
13c	Has maximum flexibility to incorporate changes in technology	4	5	5
	TOTALS	100	100	100

TABLE 7-10

SUMMARY RANKING OF GROUP 1 AND GROUP 2 CONCERNS

	1983 STANDARDS ONLY					1985 STANDARDS		
	A	B	C	E	H	D	F	G
GROUP 1 CONCERNS								
A. Heavily weighted to cost	91.85	72.27	78.56	48.07	82.54	63.59	43.48	60.09
B. Moderately weighted to cost	87.45	67.66	78.10	50.50	79.70	59.57	49.83	60.76
C. Moderately weighted to water quality	80.75	67.57	75.01	56.84	73.13	60.27	60.99	66.54
D. Heavily weighted to water quality	75.80	65.16	74.45	61.40	68.69	58.99	69.84	69.95
GROUP 2 CONCERNS								
A. Weighted to economics	63.55	57.70	58.75	67.86	61.92	59.90	76.55	61.56
B. Weighted to environmental-social	78.54	69.13	76.89	62.06	74.65	67.76	70.20	66.74
C. Balanced	71.25	63.30	69.15	64.70	68.20	66.76	72.80	64.00
COMBINED GROUPS								
0.75 x 1A + 0.25 x 2A	84.78	68.63	73.61	53.02	77.39	62.67	51.75	60.46
0.75 x 1B + 0.25 x 2C	83.40	66.57	75.86	54.05	76.83	61.37	55.57	61.57
0.75 x 1C + 0.25 x 2C	78.37	66.50	73.55	58.81	71.90	61.89	63.94	65.90
0.75 x 1D + 0.25 x 2B	76.49	66.15	75.06	61.57	70.18	61.18	69.93	69.15
0.90 x 1A + 0.10 x 2A	89.02	70.81	76.58	50.05	80.48	63.22	46.79	60.24
0.90 x 1B + 0.10 x 2C	85.83	67.22	77.20	51.92	78.55	60.29	52.13	61.08
0.90 x 1C + 0.10 x 2C	79.80	67.14	74.42	57.63	72.64	60.92	62.17	66.29
0.90 x 1D + 0.10 x 2B	76.07	65.56	74.69	61.47	69.29	59.87	69.88	69.63

Results of Step 2 Evaluation

Before proceeding to analysis of the results of the evaluation, it is of interest to note that an evaluation of Group 1 concerns by members of the Citizens Committee gave results corresponding almost exactly with the evaluation herein weighted moderately to water quality.

Considering Group 1 concerns alone, Plan A is highest ranked of plans which meet 1983 standards regardless of how the individual concerns are weighted. Other plans which meet 1983 standards have the same order or ranking, Plans H, C, B and E, regardless of weighting except for the condition of maximum weighting to water quality where ranking becomes Plan C, H, B and E. Surface water disposal in its various service area combinations occupies the three top ranking positions. In the second ranked position, only when heavy weighting is given to water quality do the advantages of a single point of treatment and disposal as represented by Plan C overcome its cost disadvantages relative to Plan H with its three separate plants.

The ranking of plans which can meet 1985 standards are more senitive to the various weighting schemes. The order goes from Plan D, G, F at maximum weighting to cost to Plan G, F, D at maximum weighting to water quality. In all cases, Plans which meet 1985 standards rank below all the plans which meet 1983 standards except the lowest ranking Plan E. Since the clearly highest ranking 1983 plan, Plan A, can be upgraded to 1985 Plans D and F, this compatibility in itself gives Plans D and F an advantage not recognized in the tabular rankings.

The weighted ranking of candidate plans for Group 2 concerns alone is more senitive to the effects of weighting than for Group 1 concerns. Also since project cost is not in Group 2, there is no consistent advantage to plans which meet 1983 standards over those which meet 1985 standards. The Group 2 weighted ranking goes from Plans F, E, A where economic concerns are given highest weight to Plans A, C, H where environmental and social concerns are given maximum weight. A balanced weighting ranks Plans F, A, C highest. The ranking within Group 2 concerns alone should not be given much significance because of the relatively greater importance of Group 1 concerns. The importance of Group 2 ranking is in their effect upon the overall ranking when combined with Group 1.

Group 1 and Group 2 concerns are combined on Table 7-10 in a variety of ways to describe the range of possible outcomes. For the intergroup weighting in which Group 1 is weighted three times Group 2, the outcome, considering Plans which meet 1983 standards, is similar to that for Group 1 alone. Plan A is ranked first for all weighting combinations, followed by Plan H where cost and economics are emphasized and by Plan C where water quality and environment are emphasized.

Plans which meet interpreted 1985 standards rank lower than the top three Plans for 1983 standards except at the level of heaviest weighting toward water quality and environment at which point Plans F and G rank second only to Plan A.

For intergroup weighting which assigns Group 1 nine times the weight of Group 2, the impact of Group 2 rankings becomes insignificant and results are substantially as described above for Group 1 alone.

The foregoing indicates that Plan A is the leading candidate for its inherent advantages of:

1. Cost

2. Protection of groundwater

3. Low energy requirement

4. Compatibility with alternative plans for advancing to 1985 requirements

5. Flexibility to include or exclude Spokane Valley without jeopardizing the plan advantages

6. Minimum disruption of the community and land use

7. Acceptable protection of surface waters through effluent standards

The surface water disposal alternatives provide protection of fishery habitat through adequate effluent standards and dilution requirements to maintain Class A stream standards backed by ongoing monitoring to guard against development of other deficiencies.

When considering interpreted 1985 requirements, Plans D and F are feasible as upgradings of Plan A. Plans D and F have most favored rankings among the group which can meet 1985 standards except under certain weighting conditions when Plan G becomes more favored. Plan G, however, is less flexible with respect to development of a low cost interim plan while 1983 standards are in force and is less flexible regarding the inclusion of Spokane Valley. For these reasons, Plan G is not suggested for further analysis.

It is suggested that Plan A be given primary consideration for implementation to meet 1983 standards with Plan H being a secondary selection. For suggestions regarding upgrading to interpreted 1985 standards further analysis is developed below.

Step 3 Evaluation, Upgrading Alternatives

It is demonstrated above that Plan A is the leading candidate to meet 1983 standards or for a step implementation plan which is capable of later upgrading. Two of the three upgrading alternatives, infiltration-percolation and land irrigation, Plans D and F respectively are explored in the process of screening for a basic alternative. It should be recognized that Plan F in the basic selection process is for implementation of land irrigation beginning in 1980. For the purpose of this subalternative study, land irrigation is being considered as a potential upgrade added to Plan A in 1990. This subalternative is designated Plan F-1. The third alternative which has not been explored is upgrading by adding advanced site-intensive treatment processes to the secondary facilities of Plan A. This plan combines elements (C+NS)-sw/swt and SV-sw/swt and is designated Plan J. Since Plan J has a cost which is intermediate between Plans D and F-1, a subalternative analysis comparing Plans D, J and F-1 as supplements to Plan A suggests itself.

A summary ranking of characteristics and concerns limited to these three alternatives all considered as upgrades to Plan A is shown in Table 7-11. The results of an evaluation of these three alternatives based on Group 1 concerns and the two moderate weightings is shown in Table 7-12. The refinement of Group 2 evaluation is not carried out based on their negligible impact demonstrated above. The Group 1 evaluations indicate Plans D and J as being distinctly more favorable than F-1 but with no strong advantage of one over the other between Plans D and J.

Keeping in mind that this evaluation is from the viewpoint of alternatives that may or may not have to be exercised and if so not until 1990, other considerations should be recognized. Most significant are that technological advances and relative cost changes could radically shift the ranking. Plan J suffers from the high cost of present known processes for nitrification-denitrification and for carbon adsorption. Increased fertilizer costs could improve the ranking of Plan F-1, as could increased need for intensive agriculture. On the other hand, increased energy costs or decreased energy availability could lower the ranking of Plan F-1.

One of the outstanding advantages of a site intensive process as exemplified by Plan J is that it can be adjusted to different levels of disposal criteria by different levels of expenditure and is not inherently an all or nothing commitment like going to percolation or land irrigation. If the future requirement is something less than what has been interpreted herein as the possible equivalent of the 1985 goal, then a modified and lower cost version of Plan J would increase its relative advantage over the land application systems.

TABLE 7-11

SUMMARY RANKING OF ALTERNATIVES FOR UPGRADE OF PLAN A

CHARACTERISTICS AND CONCERNS	Ranking of Candidate Plans D	F-1	J
1. COST EFFECTIVENESS			
a. Present worth of the sum of capital [1] and operation and maintenance costs	58.0	81.9	70.9
b. Is most cost effective	1	3	2
2. DIRECT ECONOMIC CONCERNS			
a. Has lowest requirement for capital [1]	29.3	57.5	32.0
b. Has lowest annual O&M cost [1]	28.7	24.4	38.9
c. Causes minimum loss of employment and real income due to displacement	2	3	1
d. Causes minimum loss of tax revenue due to displacement	2	3	1
3. INDIRECT ECONOMIC CONCERNS			
a. Has maximum favorable impact on attractiveness to business and rise in level of economic activity	1	3	2
4. TRANSIENT ECONOMIC CONCERNS			
a. Has maximum potential for local employment increase during construction	2	1	3
b. Has maximum potential for increase in local manufacture and supply activity during construction	2	1	3
c. Will cause minimum disruption of circulation and business activity during construction	2	3	1
5. SOCIAL CONCERNS FOR THE COMMUNITY			
a. Has most favorable impact on health, welfare and safety	2	3	1
b. Causes the least disruption to existing community living patterns	2	3	1
c. Has the most beneficial impact on availability of recreation	3	2	1
d. Introduces the least constraints to land use and land use planning	2	3	1
6. SOCIAL CONCERNS FOR THE INDIVIDUAL			
a. Causes the least dislocation of individuals from their homes, employment and general pattern of cultural activity	2	3	1
7. CONCERNS FOR GROUNDWATER			
a. Provides maximum protection of groundwater quality	3	2	1
8. CONCERNS FOR SURFACE WATER			
a. Provides maximum protection or enhancement of surface water quality for all concerns	1	1	2
9. CONCERNS FOR LAND USE			
a. Preserves or increases land available for wildlife habitat, natural vegetation and open space	2	3	1
b. Preserves or enhances the aesthetic value of the landscape	2	3	1
c. Creates least interference with other beneficial uses of land	2	3	1
10. CONCERNS FOR AIR QUALITY AND NOISE			
a. Provides maximum protection of public health aspects of air quality	1	2	1
b. Provides minimum potential for offensive odors	2	3	1
c. Provides minimum noise impact	-	-	-
11. CONCERNS FOR ENERGY AND RESOURCES			
a. Requires minimum input of electrical energy [2]	556	844	675
b. Requires minimum input of chemicals	2	1	3
c. Provides the maximum opportunity for energy and resource recovery	1	1	2
d. Has lowest net energy requirement considering recovery [2]	493	709	540
12. PERFORMANCE EVALUATION			
a. Provides best technical performance in wastewater renovation	2	1	1
b. Provides highest degree of reliability	1	2	3
13. FLEXIBILITY			
a. Has maximum flexibility to meet unanticipated changes in growth	2	3	1
b. Has maximum flexibility in adapting to changes in disposal criteria	2	1	1
c. Has maximum flexibility to incorporate changes in technology of wastewater treatment	2	3	1

1 Present worth, millions of dollars over 20-year planning period
2 Cumulative energy use 10^5 kwh over 20-year planning period

TABLE 7-12

RANKING OF GROUP 1 CONCERNS,
ALTERNATIVES FOR UPGRADE OF PLAN A

	Weighted Ranking of Candidate Plans		
	Plan D	Plan F-1	Plan J
Moderately Weighted to Cost	90.7	73.0	89.1
Moderately Weighted to Water Quality	88.0	77.6	91.6

The primary result from this exploration of alternatives to upgrading of Plan A is to demonstrate the advantage of Plan A as the initial implementation for its flexibility in being compatible with several upgrading alternatives and the advantage of gaining time to resolve the future selection. None of the three alternatives should be excluded from further consideration at this time. Plan D remains a favored choice pending whatever development the future may bring between now and 1990.

Comparison of Action and No Action Plans

Definition of the "No Action" Plans. It is not useful to consider a single regional no action plan since the three service area elements are so differently impacted by a "no action" approach. The three service area elements have individual "no action" plans defined as follows:

1. The City alone would be served by the City STP, upgraded and enlarged in accordance with the current commitment, and suburban areas in Moran Prairie and Southwest would continue with individual on-site disposal.

2. North Spokane would continue with a mixture of individual on-site disposal and grouped on-site (interim) disposal.

3. Spokane Valley would continue with individual on-site disposal.

Costs. The candidate action plans are compared by cost-effective analysis excluding the cost of any required internal sewage collection systems. In making a comparison between the no action plan and all action plans the cost of new internal collection systems becomes a major consideration to be measured against the cost of on-site disposal facilities.

For the City service area, the no action plan is essentially equal to plan element C-sw except for the exclusion of Moran Prairie and Southwest. The primary costs for this plan element are the operation and maintenance costs for the City's enlarged and upgraded STP, for which the capital costs are sunk costs. Since the City is sewered, the future internal sewerage costs are limited to extensions to new growth where needed, but most population increase will undoubtedly be served from existing sewers. Therefore, the costs for the City element of the no action plan are judged to be not significantly different than the C-sw element.

For the North Spokane and Spokane Valley service areas which are presently served by on-site or interim disposal facilities there are large costs for internal sewage collection for all action plans to serve the existing residents as well as the costs for extensions to serve future residents. Offsetting these costs, the no action plan has costs for the individual on-site facilities for future residents. The difference between these two internal costs, plus the action plan external costs for conveyance, treatment and disposal, represents the net cost of the action over the no action plan. This cost comparison in terms of present worth of capital expenditures is summarized in Table 7-13 for the North Spokane and Spokane Valley service areas.

TABLE 7-13

COST ADVANTAGE OF NO ACTION OVER
LOWEST COST ACTION PLANS
FOR NORTH SPOKANE AND SPOKANE VALLEY

	Present Worth Costs, Dollars	
	North Spokane[1]	Spokane Valley[2]
Structural Alternative for surface water disposal	$11,300,000	$16,000,000
Internal sewer collection system	17,200,000	52,700,000
Subtotal, lowest cost action plan	$28,500,000	$68,700,000
Capital Cost of On-Site Facilities for "No-Action" Plan	$ 2,600,000	$ 2,300,000
Net incremental cost of lowest cost action plan above the "No Action" Plan	$25,900,000	$66,400,000

[1]Assuming initial operation in 1980.

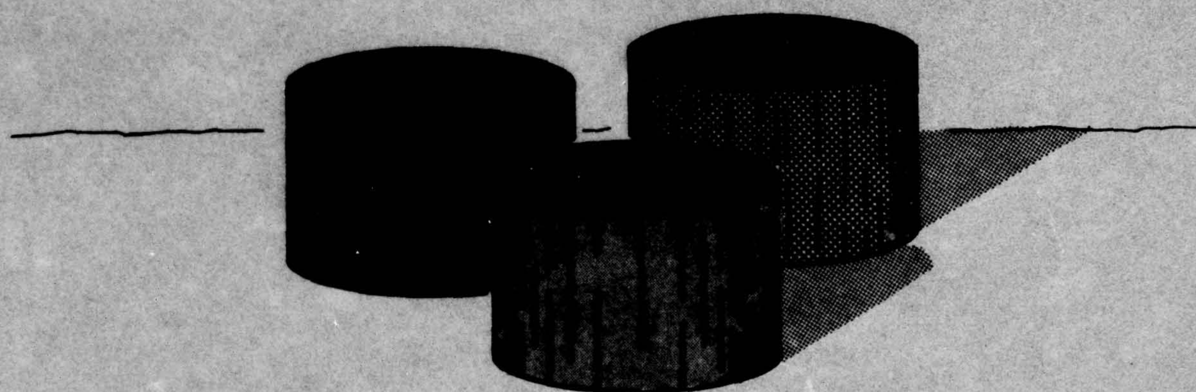
[2]Assuming initial operation in 1985, and expressed at present worth at 1985.

There is no question that the cost advantages of the no action plans for North Spokane and Spokane Valley are enormous and impact not only the decision process when weighed against other concerns but the feasibility of implementation.

Evaluation of Other Concerns. Many of the concerns selected for evaluation of the action structural alternatives are not applicable to the no action plan or are insignificant in comparison with the cost difference between action and no action plans. Significant concerns that can justify the large expenditures required to implement action plans for either North Spokane or Spokane Valley are public health, water quality and land use.

In the case of North Spokane, the failure of septic tank drainfields proposed land use in this area as the most rapidly growing suburb is argument in favor of an action plan, since without such a plan the required density of development would be impossible. The fact that the majority of the development is still in the future is also a strong argument for early implementation. This means that each year of delay produces more sunk and irretrievable costs in on-site and interim facilities. An action plan can be suggested on these grounds for North Spokane and appears to be generally supported by local public opinion.

In the case of Spokane Valley there is little difficulty with surfacing drainfield effluent. The primary concern for health and water quality is with respect to the impact of drainfield effluent on groundwater. This concern and the decision process for its resolution are fully discussed in Section 8. The lower forecast growth rate in Spokane Valley weakens the argument for early implementation based on minimizing future sunk costs in on-site facilities. Public opinion at this time does not recognize the early need for an action plan in the Spokane Valley.



SECTION 8

SEWAGE SOLIDS MANAGEMENT ALTERNATIVES

8. Sewage Solids Management Alternatives

Introduction

Objectives. Alternative wastewater management plans have thusfar been evaluated as systems with a single common sewage solids (sludge) treatment and disposal system. It is now necessary to formulate and evaluate the variety of sludge disposal systems that are possible through available technology and specific site considerations. To complete the interactive approach to wastewater plan selection, it is then necessary to determine the impact of the findings on sludge systems on the wastewater plan selection.

Federal Guidelines. The latest guidelines for sludge disposal were promulgated in November 1974 in draft form by EPA under the title "Acceptable Methods for the Utilization and Disposal of Sludges." This document is devoted primarily to setting criteria for land application alternatives rather than as a canvas and evaluation of all possible techniques. This document fills an important need relative to land disposal that had not been previously covered and is not yet as well covered for disposal of wastewater itself. The salient requirements set forth in this document are summarized in Section 4, Water Quality Goals and Disposal Criteria.

Committed Facilities. The sludge processing elements of the committed expansion and upgrading of the City treatment plant are regarded as existing and as comprising sunk costs in cost-effectiveness analysis. The committed expansion and upgrading provides anaerobic digestion and vacuum filtration facilities for 40 mgd capacity sized to handle sludge produced by year-round phosphorus removal accomplished by alum precipitation in the secondary in addition to the normal primary and waste activated sludges.

The sludge facilities being incorporated in the proposed enlargement are as follows:

1. Gravity thickeners for primary sludge.
2. Flotation thickeners for waste activated sludge.
3. Three anaerobic digesters at 275,000 cubic feet each.

4. Six vacuum filters, each 12 feet diameter by 16 feet long.

5. Four trucks for sludge cake haul to landfill.

All wastewater alternative plan elements which utilize the City STP share the situation where complete anaerobic digestion and vacuum filtration facilities are provided as a sunk cost.

Concurrent Sludge Disposal Study

Concurrent with this study the State DOE had a study prepared by Bovay Engineers, Inc., on alternatives for sludge disposal of the committed City STP upgrade and expansion. The study titled "Report on Feasibility Study of Wastewater Solids Application to Land for Spokane, Washington," was completed in May 1975. Since this report addresses alternatives for disposal of sludge resulting from a flow of 40 mgd to the City STP, it is specifically applicable to the leading candidate wastewater plan developed in this study. Plan A, combining City and North Spokane flows to the City STP, will generate forecast flows of 40 mgd at year 2000. Maximum use is made of the DOE study in the analysis for this study. Although maximum use is made of the DOE study, it does not provide all of the documentation of the decision processes for a regional study. This study meets those needs, beginning with a formulation of sludge system alternatives.

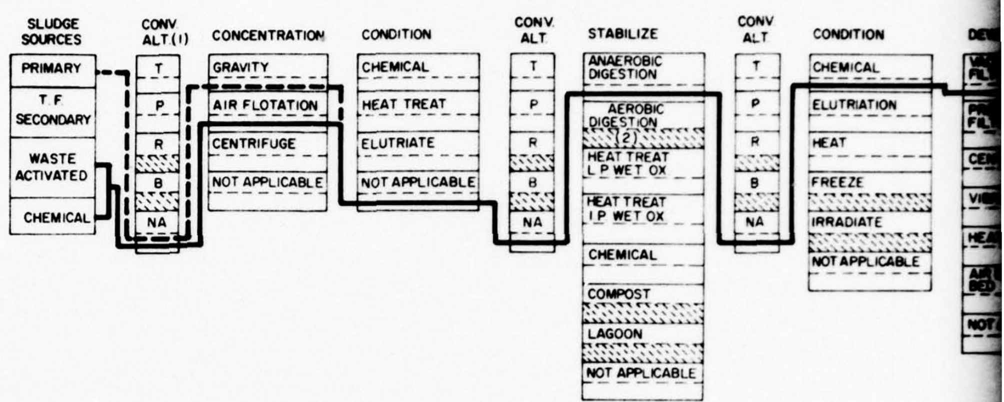
Formulation of Alternative Plans

A decision tree for the development of sludge systems is shown in Figure 8-1. From consideration of this decision tree and the constraints of individual processes the following candidate plans are developed.

Plan S. This plan consists of sludge stabilization, dewatering and disposal of dewatered cake to sanitary landfill. Subalternatives considered for stabilization include aerobic digestion, anaerobic digestion, chemical treatment, heat treatment and lagooning. Subalternatives considered for dewatering are vacuum filtration, pressure filtration, centrifugation and drying beds.

Anaerobic digestion is selected and the representative stabilization process and heat treatment is selected as a subalternative for second stage or design stage reconsideration. Aerobic digestion is eliminated as not cost-effective except in very small sizes. Chemical treatment is eliminated for cost reasons and the fact that it does not provide any reduction of volatiles or volume. Lagoons are judged to be infeasible throughout the study area because of their nuisance potential and space requirements when applied at a plant site.

ALTERNATIVE PROCESSES BY FUNCTION



NOTES:

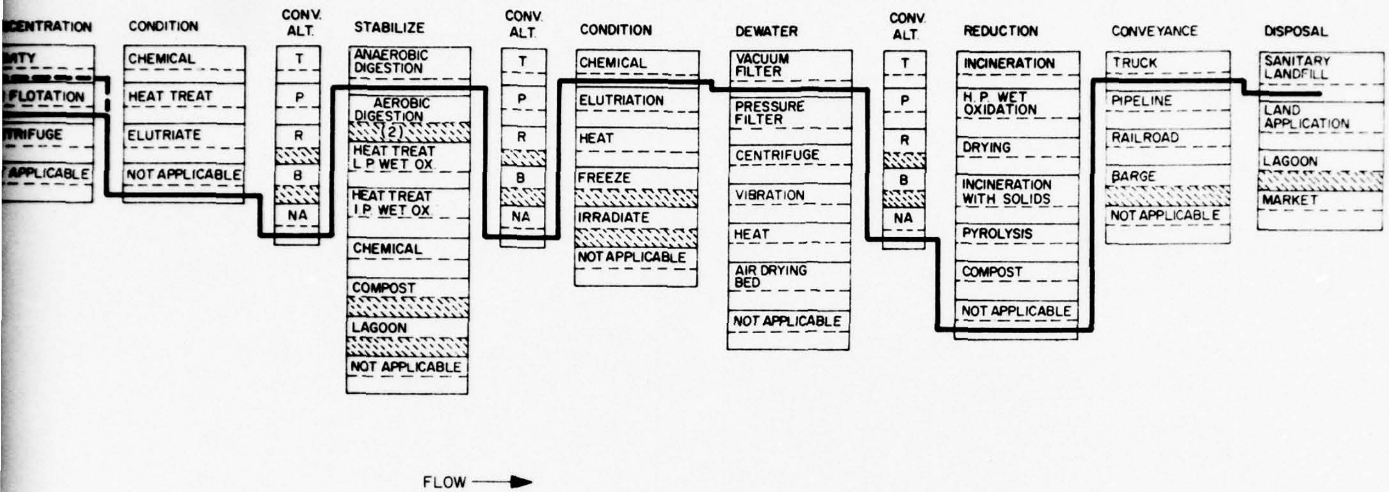
(1) CONV. ALT. indicates alternatives sequence of conveyance

(2) Cross hatching indicates alternative not applicable to this study

(3) Path illustrates decisions for Plan S as proposed for City STP by Bovay (1975)

2

ALTERNATIVE PROCESSES BY FUNCTION



lternatives sequence of conveyance

alternative not applicable to this study

for Plan S as proposed for City STP

FIGURE 8-1

DECISION TREE FOR SOLIDS PROCESSING ALTERNATIVES

Vacuum filtration is selected as the representative dewatering process. Centrifugation and pressure filtration are considered equal alternatives on a cost level but the factors affecting choice in performance between vacuum filtration, pressure filtration and centrifugation are so specific to the properties of the sludge that the choice is a design level process. Drying beds are eliminated from this alternative plan, which is to represent processes feasible at the treatment plant site, due to the space requirements. Drying beds are incorporated in another plan for remote location.

In summary, the basic Plan S consists of anaerobic digestion, vacuum filtration and truck haul to sanitary landfill. Also included are concentration of raw sludges as necessary for optimum use of digestion tank volume and reconcentration and conditioning before vacuum filtration, again to provide optimum utilization. For the subalternative utilizing heat stabilization, a process comparable to Zimpro Intermediate Pressure Oxidation is selected.

The basic Plan S is equal to the committed facilites in the expanded and upgraded City STP and is representative of the comparable alternative in the DOE study (Bovay 1975).

A potential subalternative for disposal of the dried sludge cake is application to agricultural lands or greenbelts. In the case of agricultural lands there has not yet developed a fertilizer cost situation in which the agriculturalist will seek out and use sludge at his own application expense. A first step would probably consist of making the sludge available as a stockpile in agricultural areas, which would have a higher haul cost than landfill but would eliminate the landfill operation, judged a trade-off. In the case of greenbelts, the owner agency is the same public who pay for wastewater treatment and disposal. Therefore, the haul and application costs are essentially public costs, again a probable trade-off to landfill disposal. From a cost standpoint these subalternatives are judged to be adequately represented by the basic sanitary landfill disposal. These subalternatives have their place of recognition in environmental considerations and possible implementation at a later date. The sanitary landfill method would be a necessary fallback position when total production is not taken by these potential beneficial uses.

Plans T-1 and T-2. These plans utilize the agricultural land application of stabilized liquid sludge. Plan T-1 provides for application to dryland agriculture and Plan T-2 provides for application to irrigated agriculture. These two land application systems correspond to the systems explored in Bovay (1975).

Stabilization subalternatives considered comprise the same field discussed above under Plan S and for the reasons given above anaerobic digestion is selected as the representative process.

Subalternatives considered for transport of the liquid sludge to areas of application are truck haul and pipeline. These subalternatives must be kept open since cost-effectiveness is a function of the combination of distance and quantity.

There are a number of subalternatives to be considered for the process of distribution and application of the agricultural land. These, like the transport subalternatives, are affected by distance and quantity as well as by whether applied to dry-farmed or irrigated land and must be kept open for analysis on an individual basis.

The climate which produces a long season of frozen grounds and the specific cropping practices place constraints on the times at which liquid sludge can be applied to the soil. These constraints in combination with the large volumes of daily sludge production produce a requirement for large volumes of storage, volumes not feasibly provided at treatment plant sites. Therefore, large volume storage at remote sites is a required process element together with appurtenances to withdraw from storage for application.

The elements of Plans T-1 and T-2 cannot be described specifically for all applications due to the number of open subalternatives. In general terms a typical Plan T consists of the following elements:

1. Anaerobic digestion.

2. Transport from the treatment to application site

    a. By pump stations and pipeline
    b. By tank truck

3. Seasonal storage at the application site in lined earth ponds complete with dredge for withdrawal.

4. Application facilities.

    a. Distribution
        (1) Pump and pipelines
        (2) Tank truck
        (3) Mixed with irrigation waters
    b. Spreading
        (1) Piped sprinklers
        (2) Vehicular spray or injector
        (3) Mixed with irrigation waters

The criteria to be met in detailed formulation of sludge land application plans are contained in EPA draft supplement to Federal Guidelines issued November 1974 titled "Acceptable Methods for Utilization or Disposal of Sludges."

Plan U. This plan provides for air-drying of stabilized sludge with disposal of the dried cake to sanitary landfill. Subalternatives considered for stabilization are as discussed for Plan S above with anaerobic digestion selected as representative. Subalternatives considered for transport of liquid stabilized sludge to the drying bed site are pipeline and truck haul.

Climate again provides a constraint on the air-drying season with open beds. Subalternatives considered are enclosed beds for year-round operation (at greatly reduced winter rates despite shelter) and open beds for seasonal operation with between season storage. Open beds of much lower cost are selected as representative.

Plan U typically consists of the following process elements:

1. Anaerobic digestion.
2. Transport of liquid sludge to drying site.
   a. Pump station and pipeline
   b. Tank truck
3. Seasonal storage in lined earth pond with dredge withdrawal.
4. Open air-drying beds, underdrained. (Underdrainage returned to the treatment plant by parallel pipe transport or return truck trip.)
5. Load and transport dried sludge to sanitary landfill.

The drying beds would be located typically near a remote sanitary landfill.

The agricultural or greenbelt application subalternatives discussed under Plan S are equally applicable to Plan U. The same conclusion is reached that the basic sanitary landfill subalternative adequately represents the costs for both but that recognition should be given to potential environmental differences.

Plans V-1 and V-2. These plans provide for incineration of sludge to an ash residual which is disposed to sanitary landfill. All incineration subalternatives require pretreatment by mechanical dewatering to reduce fuel requirements to feasible levels. Subalternatives considered for the pretreatment are centrifuge dewatering of raw sludge and vacuum filtration dewatering of digested sludge. The former is significantly more cost-effective but the latter is included to represent the plan analyzed in the DOE study (Bovay 1975).

Subalternatives considered for the incineration process itself are multiple-hearth and fluidized bed. The final selection is considered a design level analysis. Multiple-hearth incineration is selected as representative because more extensive cost data are available.

Plan V-1 consists of raw sludge conditioning, dewatering by centrifugation, multiple-hearth incineration and ash disposal by sanitary landfill. Plan V-2 consists of anaerobic digestion, vacuum filter dewatering, multiple-hearth incineration and ash disposal by sanitary landfill.

Plan W. This plan provides for production of a dried and sterilized sludge suitable for marketing to the general public. The finished product has 5.5 percent moisture and contains about 5.3 percent nitrogen and 3.9 percent phosphorus (EPA Tech Trans Sludge). The process usually consists of dewatering raw sludge by centrifugation or vacuum filtration and flash drying in special equipment similar to C-E Raymond. As utilized in the DOE study for the City STP, a subalternative process is used which includes digestion, vacuum filtration and flash drying. No net return on the product is credited. It is assumed that the dried product would be furnished at no cost to others for enrichment with fertilizer chemical, packaging and marketing.

Plan X. This plan provides for wet oxidation of conditioned raw sludge with centrifuge separation of the inert residual and truck haul to sanitary landfill. The wet oxidation process is assumed to be equal to Zimpro High Pressure Oxidation which produces a 70 percent oxidation.

Significance of the DOE Study to Alternative Screening

The DOE study (Bovay 1975) analyzes the economics and environmental impact of the application of liquid stabilized sludge to dry and irrigated agriculture from the proposed enlarged and upgraded City STP. The economic elements of the study are for the STP operating at its design capacity of 40 mgd and with year-round 85 percent phosphorus removal. Disposal sites are considered in an area up to 30 miles from the STP. Following a detailed analysis of site specific land application alternatives, the highest ranked is compared with three non-land application alternatives.

The cost-effective and envionmental screening in the DOE study of alternative land application sites for sludge is directly applicable to all City combined alternatives. Application to dryland agriculture is identified as more cost-effective than to irrigated agriculture, and the region extending from Indian Prairie west to Reardan is determined to be the most favorable location from both cost and environmental impact considerations. At design loading conditions, the area required is estimated at from 6000 to 8000 acres for dry and 2000 to 3000 acres for irrigated application. The criteria limiting application rate is the ability of the crop to assimilate the nitrogen content of the sludge. Life of the application sites receiving sludge is estimated on the basis of the cation exchange capacity of the soil to fix toxicants. The estimates range from 57 years for irrigated to 168 years dry farmed land.

The three non-land application alternatives considered in the DOE study are Plans S, V and W. Cost comparison of these three plans with the land application Plans T-1 and T-2 are shown in Table 8-1.

TABLE 8-1

COST-EFFECTIVE ANALYSIS OF SLUDGE MANAGEMENT ALTERNATIVES FOR CITY STP

Sludge Alternatives	Description	Average Annual Cost[1] Thousand Dollars		
		Capital	O&M	Total
S	Anaerobic digestion, vacuum filtration, sanitary landfill	458	626	1,084
T-1	Anaerobic digestion, dry farm land application[2]	1,058	433	1,491
T-2	Anaerobic digestion, irrigated land application[2,3]	1,449	624	2,073
V	Anaerobic digestion, vacuum filtration, incineration, landfill	601	895	1,596
W	Anaerobic digestion, vacuum filtration, drying, marketing	733	1,114	1,848
(X	Wet oxidation)[4]			

Source: Bovay 1975.

[1]Costs do not include either capital or O&M costs for anaerobic digestion which is common to all alternatives as formulated in Bovay (1975).
[2]Land application costs are for Site 6 as described in Bovay (1975).
[3]Costs for Site 4 are lower than Site 6 but by an insignificant amount.
[4]Not included in the referenced source.

Analysis of three non-land application alternatives determined that digestion-vacuum filtration-landfill at \$90 per ton of dry solids was more cost-effective than vacuum filtration-incineration at \$133 per ton or vacuum filtration-drying at \$163 per ton. The most favorable agricultural land application system and location will have total costs of \$123 per ton of dry solids as compared with \$90 per ton for vacuum filtration and sanitary landfill. These comparisons include all costs for both systems; the proposed facilities now under construction are not regarded as sunk costs. The basic economic analysis of land appli-

cation alternatives does not take credit for the value of commercial fertilizer displaced by nitrogen in the applied sludge. A separate calculation for the most favorable site under dry-farming conditions concludes that the disposal cost per ton would be reduced from $123 to $116.[1/] This calculation is based on a current price of $0.22 per pound of nitrogen available in commercial ammonia fertilizers. The DOE study does not draw a direct conclusion from this recognition of the possible effect of fertilizer value, but it is obvious that, at present fertilizer prices, the inclusion of their value does not make land application less costly than vacuum filtration and landfill.

The DOE study concludes that land application is feasible but more costly than vacuum filtration and sanitary landfill. A suggestion is made that additional on-site agronomic studies be made to establish firm criteria for land application before full scale operation is actually undertaken. There is no suggestion either to continue with the planned vacuum filtration and sanitary landfill or to change to agricultural land application. Presumably, the suggestion is to continue with vacuum filtration and sanitary landfill while making additional tests for land application and monitoring progress in the field nationally. It is pointed out that the present unfavorable cost for agricultural land application may change as future increases in chemical and energy prices raise the cost of vacuum filtration and future increases in fertilizer costs make the nutrient value of sludge more attractive to the farmer.

Cost-Effectiveness of Sludge Plans for City STP

Comparison of Table 8-1 with the alternative sludge disposal systems developed in a previous paragraph indicates that the DOE study includes all except the following:

Plan	Description
U	Digestion, air drying at a remote site and disposal to sanitary landfill
V-1	Centrifugation and incineration
X	Wet oxidation

[1/] This calculation on per ton basis does not appear in Bovay (1975); it is shown in annual cost form at $1,398,500 for 12,045 tons per year.

Plan U is generally not considered practical for plants for over 10 mgd, let alone 40 mgd, and is omitted as inappropriate. The incineration alternative is considered to be adequately represented by Plan V-2 so that V-1 need not be considered, particularly from the viewpoint of this study in which part of the facilities required for V-2 are sunk costs.

It is useful to consider Plan X regardless of its known cost disadvantages because it represents an alternative with significantly different environmental impacts. For the purpose of environmental evaluation, Plan X is assigned cost ranking equal to incineration, its competition for maximum reduction. This allows the environmental differences between the two alternatives to be unobscured by cost differences.

Consideration of the summarized cost-effective data in Table 8-1 shows the strongly favorable position of Plan S relative to the second place alternative Plan T-1. It should be kept in mind that the figures shown for Plan S as taken from the DOE study do not consider the anaerobic digestion and vacuum filtration equipment committed to construction as a sunk cost. From the viewpoint of this study where these committed facilities are sunk costs, there is in effect no contest since the capital cost component for Plan S would be zero.

Evaluation of City STP Alternatives for Economic, Social and Environmental Concerns

The DOE study does not provide an environmental screening of sludge alternatives other than that comparing land application sites. This study fulfills the need for an evaluation of all alternatives for economic, social and environmental concerns. The methodology used is as outlined above for wastewater plans, modified to give greatest emphasis to those concerns critically affected by sludge management alternatives and to eliminate those with small or negligible impacts. The primary areas of impact for sludge management alternatives are as follows:

1. Health, general
2. Groundwater quality
3. Surface water quality
4. Health aspects of air quality
5. Aesthetic aspects of air quality
6. Thermal energy
7. Electrical energy
8. Chemical consumption
9. Salvage of resources
10. Effect on wastewater quality
11. Reliability

The summary of the evaluation are shown in Table 8-2.

TABLE 8-2

SUMMARY RANKING OF GROUP 1 AND GROUP 2 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP

	Alternative Plans					
	S	T-1	T-2	V	W	X
GROUP 1 CONCERNS						
A. Heavily weighted to cost	93.1	73.6	61.9	71.9	68.0	70.4
B. Moderately weighted to cost	90.0	74.1	66.1	73.5	71.9	71.3
C. Moderately weighted to environmental	86.1	74.5	71.5	75.9	77.2	72.9
D. Heavily weighted to environmental	84.5	74.5	74.1	77.0	79.4	73.8
GROUP 2 CONCERNS						
E. Balanced weighting	79.8	58.0	70.7	83.0	82.4	84.0
COMBINED GROUPS						
0.75A + 0.25E	89.8	69.7	64.1	74.7	71.6	73.8
0.75B + 0.25E	87.4	70.1	67.2	75.9	74.5	74.5
0.75C + 0.25E	84.5	70.4	71.3	77.7	78.5	75.7
0.75D + 0.25E	83.3	70.4	73.2	78.5	80.2	76.4
0.90A + 0.10E	91.8	72.0	62.8	73.0	69.4	71.8
0.90B + 0.10E	89.0	72.5	66.6	74.4	73.0	72.6
0.90C + 0.10E	85.5	72.8	71.4	76.6	77.7	74.0
0.90D + 0.10E	84.0	72.8	73.8	77.6	79.7	74.8

Interpretation of Evaluation for City STP Alternatives

When group 1 and 2 concerns are combined in various weighting combinations on Table 8-2, Plan S is found to have the highest ranking in all cases. Since cost forms an important part in the ranking of Plan S, it is significant to refer to the weighting combination which most strongly favors social and environmental concerns for interpretation relative to the other plans.

The line on Table 8-2 with 75 percent weight to Group 1, heavily weighted to environmental, illustrates this situation. The maximum reduction plans are found to rank second after Plan S and the land application plans lowest. Note that Plan W which includes resource recovery is the highest ranking of the maximum reduction plans. Plan X has the lowest rank among the maximum reduction alternatives despite being assigned a cost ranking equal to Plan V. This indicates overall environmental rank lower than Plan V. The relatively low ranking of the land application plans is due in part to the very high costs for this specific locality which requires long pipelines, high lifts and low application rates over a short season.

The conclusion is clear that Plan S is the best alternative for immediate implementation even without consideration of the fact that, for this study, the facilities are a sunk cost. Plan S not only has merit in itself but is a steppingstone and backup position to other alter-

natives. If a land application plan is developed, the digestion facilities of Plan S are an essential element and the vacuum filters provide an alternative operation for reliability. Similarly, if a maximum reduction alternative is developed, both the digestion and vacuum filtration facilities are usable elements in some and an alternative to give reliability for all.

The primary benefit to be derived from land application alternatives is resource recovery. It is not a way to "get-rid-of" sludge with the least unfavorable environmental impacts. The DOE study points out that the importance of resource recovery is probably subject to a significant increase in the near future as the availability and cost of fertilizer changes. For this reason, a reevaluation should be made as these economic forces change. Meanwhile, there are many technical and cost problems to be solved and this study concurs with the DOE study in suggesting that a continuing program be undertaken to develop data specific to the Spokane area while continually monitoring the progress in this field throughout the country. Since there are many technical uncertainties at this time, the cost estimates currently made for land application must reflect these uncertainties. Therefore, the conclusions drawn at this time must not be regarded as fixed but should be reviewed and updated as more refined data becomes available.

The apparent second place position of the maximum reduction alternatives is also subject to change. The increase in energy costs are likely to lower their ranking while the same economic forces are raising the ranking of land application. The only reason for going to one of the maximum reduction plans from Plan S would be because either the space for or distance to wet cake disposal sites becomes prohibitive. The critical air pollution situation in Spokane is a strong negative factor against any incineration process. Even with the best emission control technology, there would be strong public pressure against any addition to the air pollution load while others are being pressured to reduce their input. For these same reasons it seems unlikely in the near future that the City would consider incineration of their solid wastes, either as an energy recovery measure or a bulk reduction measure. In the event that solid waste incineration should be considered, the disposal of sewerage sludge in the same facility becomes an attractive alternative for reconsideration.

Sludge Alternatives for Spokane Valley

Wastewater alternative Plan A provides a separate biological secondary treatment plant for Spokane Valley located in the vicinity of the east end of Felts Field for surface water disposal. The plant would be constructed in one stage at 10 mgd capacity to serve from 1980 to 2000. Alternative sludge management plans in combination with this specific wastewater management plan are formulated from the generalized list previously developed. Basic sludge quantities for the Spokane Valley service area used in formulation of sludge alternatives are for a wastewater treatment plant with biological secondary treatment and seasonal phosphorus removal.

The selected list of alternative plans is as follows:

Plan Identification	Description
S	Anaerobic digestion, vacuum filtration, sanitary landfill
T	Anaerobic digestion, vacuum filtration, land application to dry farm
U	Anaerobic digestion, air drying, sanitary landfill
V-1	Centrifugation of raw sludge, multiple-hearth incineration
V-2	Anaerobic digestion, vacuum filtration, multiple-hearth incineration
X	Wet oxidation (70% reduction), centrifuge separation of solids
Y	Deliver raw sludge to City STP for processing and disposal

All of the above listed candidate plans except for Plan Y have been discussed above in connection with alternatives for the City STP. Note that Plan T-2 for irrigated land application has been eliminated based on its unfavorable ranking compared with dry land application as determined for the City. Also, Plan W, sludge drying for marketing, is eliminated since it is not generally favorable for small communities, although there are examples as low as 10 mgd, such as Schenectady, N.Y.

Plan V-1, incineration of raw sludge, is introduced to contrast costs with that of incineration of digested sludge, Plan V-2. This relationship is not previously developed for the City.

Plan Y is developed to represent the subalternatives by which raw sludge from the Spokane Valley could be conveyed to the City STP for processing and disposal. Three conveyance subalternatives are considered: (1) tank truck haul, (2) conveyance in the City sewage collection system which extends to Felts Field and (3) pump stations and force mains. Although conveyance in the City sewers would have the lowest cost, it is eliminated at this time because it would be an intolerable addition to the present overflow problem. If it were not for the overflow problem, the conveyance of sludge mixed with raw sewage in this manner is feasible. An example is the City of Glendale, California, which returns raw sludge from a secondary treatment plant

to a City of Los Angeles trunk sewer for processing and disposal. A substudy indicates that pipeline conveyance is slightly more cost-effective than tank truck haul. Parallel lines are provided for maintenance and continuity of service.

Cost-Effectiveness of Sludge Plans for Spokane Valley

Cost-effective results of the above described alternative plans are summarized in Table 8-3. Note that these results are expressed in terms of present worth for the 20-year planning period 1980 to 2000 consistent with the methodology developed for this study. (The previously discussed cost-effective analysis for the City is in terms of average annual costs as they are expressed in the DOE study.)

TABLE 8-3

COST-EFFECTIVE ANALYSIS OF SLUDGE MANAGEMENT ALTERNATIVES FOR SPOKANE VALLEY ELEMENT OF PLAN A

		Present Worth, Million Dollars 1980-2000 Planning Period		
Sludge Alternative	Description	Capital Cost	O&M Cost	Total Cost
S	Anaerobic digestion, vacuum filtration, sanitary landfill	1.62	2.13	3.75
T	Anaerobic digestion, dry farm land application	3.73	1.73	5.46
U	Anaerobic digestion, air drying, sanitary landfill	3.61	2.30	5.91
V-1	Centrifugation of raw sludge, multiple-hearth incineration	2.31	1.83	4.14
V-2	Anaerobic digestion, vacuum filtration, multiple hearth incineration	3.02	2.23	5.25
X	Wet oxidation (70%), centrifuge separation of solids, sanitary landfill	3.79	2.29	6.08

Plan S is found to be most cost-effective of the plans which provide for an operation independent of the City operation. The system next lowest in total cost after Plans S and Y is Plan V-1, which provides for incineration of raw sludge solids. The reliability weakness of this system is considered under the screening for other than cost concerns. Plan V-2, which is in effect Plan S plus incineration and therefore high in reliability, is next in cost-effectiveness. The distances for conveyance to the nearest suitable sites for Plans T and U are prime contributors to their position of relatively low cost-effectiveness. The wet air oxidation process to 70 percent reduction has the highest cost.

Plan Y which provides for conveyance to the City for sludge processing is estimated to have costs comparable to Plan S, but the cost determinations are highly uncertain due to the questions surrounding a fair assignment of costs at the City STP. The most significant reservation concerning Plan Y is the possibility that the solids processing capacity at the City STP may not be enough to include Spokane Valley without additions.

Economic, Social and Environmental Evaluation of Sludge Plans for Spokane Valley

Following methodology described above for the City STP alternatives, an evaluation is made of Spokane Valley alternatives, results of which are summarized in Table 8-4.

TABLE 8-4

SUMMARY RANKING OF GROUP 1 AND GROUP 2 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY

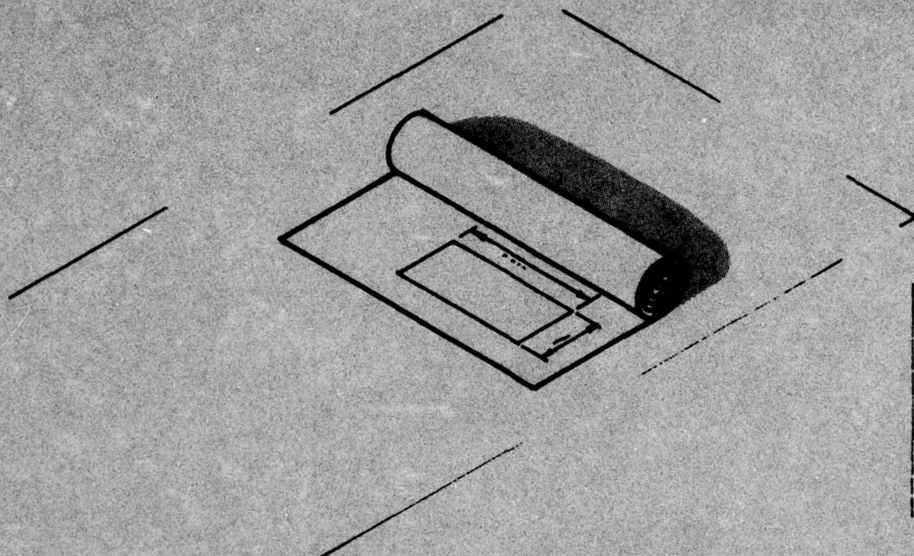
	Alternative Plans					
	S	T	U	V-1	V-2	X
GROUP 1 CONCERNS						
A. Heavily weighted to cost	93.0	70.8	64.8	86.0	73.5	66.4
B. Moderately weighted to cost	89.9	71.7	65.5	83.7	74.3	68.2
C. Moderately weighted to environmental	85.9	72.7	66.6	81.0	75.9	70.9
D. Heavily weighted to environmental	84.2	73.1	67.0	79.7	76.6	72.3
GROUP 2 CONCERNS						
E. Balanced weighting	79.1	69.3	80.8	87.4	84.1	86.8
COMBINED GROUPS						
0.75A + 0.25E	89.5	70.4	68.8	86.4	76.2	71.5
0.75B + 0.25E	87.2	71.1	69.3	84.6	76.8	72.8
0.75C + 0.25E	84.2	71.8	70.2	82.6	78.0	74.9
0.75D + 0.25E	82.9	72.2	70.4	81.6	78.5	75.9
0.90A + 0.10E	91.6	70.6	66.4	86.1	74.6	68.4
0.90B + 0.10E	88.8	71.5	67.0	84.1	75.3	70.1
0.90C + 0.10E	85.2	72.4	68.0	81.6	76.7	72.5
0.90D + 0.10E	83.7	72.7	68.4	80.5	77.4	73.8

Plan S is found to be the most favored for all weighting conditions. The incineration plans follow. Land application ranks low and air drying at a remote location lowest. Despite the ranking position of incineration in the evaluation process, the acceptability is rated low and is not recommended to be considered in its apparent rank.

Since the most favored plan for the City STP is Plan S and the most favored plan for Spokane Valley is Plan S, the considerations of Plan Y for Spokane Valley means that the Plan S activities at the Spokane Valley facilities would be transferred to and combined with those at the City STP. The negative environmental impacts of Plan S are of the same character for both sites. Combining them to one site would undoubtedly reduce the overall negative impacts, representing a plus value for Plan Y. The most prominent negative value inherent in Plan Y is the temporary disruption that would be caused by pipeline construction through city streets.

Another plus value for Plan Y is in having all sludge processing concentrated at one location which would facilitate the adoption of new and innovative technology. For example, the feasibility of land application appears to be more favorable for the City STP than for Spokane Valley due to the advantages of size. The plus factors for Plan Y are judged to outweigh the disadvantage of temporary disruption during construciton. These, and the fact that Plan Y offers the possibility of cost savings and maximum utilization of existing facilities, are evaluated as the basis for giving Plan Y a favorable combined ranking despite the uncertainties of its cost and feasibility. The uncertainty regarding available capacity in the City STP solids facilities is the factor which precludes recommendation of this alternative as the basic plan. If the City should solve the overflow problem on its trunk sewers prior to implementation of a Spokane Valley treatment facility, Plan Y utilizing City sewers for sludge conveyance becomes even more advantageous.

Plan S is selected as the basic suggested solids processing system for the Spokane Valley for its favorable cost and environmental ranking. If at design stage, more data are available on the capacity utilization of the City STP facilities, Plan Y should be reopened for review and consideration.



SECTION 9

DEVELOPMENT OF A REGIONAL WASTEWATER PLAN

9. Development of a Regional Wastewater Plan

The Tentative Plan

Formulation and evaluation of alternative wastewater management plans for metropolitan Spokane region has thus far led to the conclusion that an optimal plan to meet the indicated criteria would be as follows:

1. Provide community sewage collection for the North Spokane area and convey the wastewaters to the committed upgraded and enlarge City STP for treatment. Provide community sewage collection for Moran Prairie and Southwest service areas as extensions of the City collection system. Operate the City STP as proposed as a secondary treatment plant with provision for phosphorus removal for surface water disposal to the Spokane River. Operate the sludge disposal facilities as currently provided with dewatering by vacuum filtration and sanitary landfill disposal.

2. Provide for a wastewater operation for Spokane Valley, whether it be no action or implementation of a community sewage collection and disposal system, which will be independent of the other regional elements of metropolitan area wastewater facilities. If a community sewage collection system is elected, the optimal treatment and disposal would consist of a treatment plant in the vicinity of Felts Field to provide secondary treatment with provision for phosphorus removal. Disposal would be to surface water of the Spokane River at a point, approximate RM 79, downstream of adjacent City wells. Sludge treatment and disposal would be by anaerobic digestion, vacuum filtration and sanitary landfill (with reconsideration at the design stage of the possibility of conveyance of raw sludge from the Spokane Valley STP to the City STP for a regional sludge operation).

These plans have been tentatively selected on the basis of cost-effective analysis and generalized economic, social and environmental evaluation. The evaluation process is further extended herein by addressing other concerns specific to the study area before giving these plans the status of a suggested plan. These specific concerns are:

1. An evaluation of the water quality performance of the Spokane River under the forecast impact of the tentative plan at year 2000 conditions, including review of phosphorus removal alternatives.

2. The potential impact of the possible beneficial combination of West Plains' flows into the regional plan.

3. The formulation of a decision process for selection of a program for Spokane Valley.

These specific problems are addressed first, followed by a summarization of the suggested plan.

Year 2000 Performance Evaluation

Full implementation of the plan for combining North Spokane and the City to surface water disposal and Spokane Valley separately to surface water disposal in accordance with alternative Plan A will result in two major point source inputs to the Spokane River, one at RM 67.2 and one at RM 79. The forecast point source loads at year 2000 are summarized in Tables 9-1 and 9-2 for the City STP and Spokane Valley STP inputs, respectively. In addition to the urban area municipal loads, the surface waters will at the same time be faced with assimilation of the forecast industrial point source loads. The municipal and industrial mass emissions are summarized in Table 9-3.

The year 2000 water quality conditions are approximated using a mathematical model capable of simulating future conditions which allow for both the increased population and the planned wastewater treatment improvements. The detailed scope, development and ongoing use of the water quality simulation model are discussed in Section 11. One of the uses of the simulation model is to test the performance of plan alternatives. Two production runs were implemented for this purpose, the results of which are summarized here because they evaluate the estimated performance of facilities at year 2000 conditions.

One production run was made for a condition in which all point sources were removed. This simulation represents natural conditions and all those alternative plans that completely eliminate surface water disposal.

The second production run was made for point source inputs corresponding to Plan A at year 2000. Plan A, which consolidates North Spokane with the City and provides for separate sewage facilities for Spokane Valley, all with discharge to surface waters, represents the most severe impact on surface waters possible under 1983 disposal criteria. In other words, these two production runs bracket the entire expected range of performance under 1983 disposal criteria.

TABLE 9-1

PROJECTED POLLUTANT LOADS - YEAR 2000, CITY STP

Parameter	Forecast Conc. in Raw Waste mg/l	Forecast Concentration in Treated Effluent mg/l: Secondary without P Removal	Secondary with P Removal	Secondary with P Removal & Nitrification	Mass Emission Rate Per Day of Treated Effluent @ 40.05 mgd[1] in Units of Pounds Per Day: Secondary without P Removal	Secondary with P Removal	Secondary with P Removal & Nitrification
BOD	212	25	21	21	8,340	7,006	7,006
Total P as P	11.5	8.0	1.4	1.6	2,669	467	534
Ortho P as P	7.7	7.82	1.25	1.45	2,609	417	484
Pot P as P	3.8	.18	.15	.15	60	50	50
Total N	33.6	19.2	19.2	19.2	6,405	6,405	6,405
NO_2+NO_3 as N	0.7	0.7	0.7	14.7	234	234	4,904
NH_3 as N	19.5	14.6	14.6	0.6	4,871	4,871	200
Org N as N	13.4	3.9	3.9	3.9	1,301	1,301	1,301

[1]For service population of 234,000 in City, Moran Prairie, Southwest and North Spokane.

TABLE 9-2

PROJECTED POLLUTANT LOADS - YEAR 2000, SPOKANE VALLEY STP

Parameter	Forecast Conc. in Raw Waste mg/l	Forecast Concentration in Treated Effluent, mg/l: Secondary without P Removal	Secondary with P Removal	Mass Emission Rate Per Day of Treated Effluent @ 10.03 mgd[1] in Units of Pounds Per Day: Secondary without P Removal	Secondary with P Removal
BOD	186	25	21	2,089	1,755
Total P as P	10.6	8.0	1.40	668	117
Ortho P as P		7.82	1.25	653	104
Pot P as P		.18	.15	15	13
Total N	31	19.2	19.2	1,604	1,604
NO_2+NO_3		0.7	0.7	58	58
NH_3	18.6	14.6	14.6	1,220	1,220
Org. N	12.4	3.9	3.9	326	326

[1]For service population of 74,000

TABLE 9-3

PROJECTED TOTAL POLLUTANT LOADS - YEAR 2000, MUNICIPAL AND INDUSTRIAL

Area	Mass Emissions in Pounds Per Day — During P Removal Season: BOD	Total P	Total N	Without Municipal P Removal: BOD	Total P	Total N
City STP	7,006	467	6,405	8,340	2,669	6,405
Spokane Valley STP	1,755	117	1,604	2,089	668	1,604
North Spokane Industrial	120	4	18	120	4	18
Spokane Valley Industrial	1,588	79	298	1,588	79	298
Urban Area Totals	10,469	667	8,325	12,137	3,420	8,325
Deer Park	47	15	36	47	15	36
Tekoa	21	7	16	21	7	16
TOTAL Reaching Spokane River	10,537	689	8,377	12,205	3,442	8,377

The Plan A, year 2000 run is for seasonal phosphorus removal rather than year-round removal in order to test the validity of this approach. Simulated water quality at three significant locations is shown in Table 11-1 contrasting no-point-source (NPS) and Plan A conditions.

The simulation period is a continuous dynamic one for the meteorologic and flow conditions of record for the period May 1968 through September 1969. This period was selected because it provides examples of low runoff, year 1968, and high runoff, year 1969.

The primary focus of public and regulatory agency concern has been on the quality of Long Lake and particularly to its eutrophic state which has been the basis for establishment of phosphorus removal requirements. The following findings and conclusions about the forecast performance of Long Lake are derived from analysis of the simulation results of the two runs.

1. Complete removal of point source loads will not completely eliminate algae growth. Significant chlorophyll A (chlor. A) levels, above 7 micrograms per liter (ug/l), will occur in May and after the fall turnover. Mid-summer conditions, July and August, will be very good with chlor. A concentrations of less than 2 ug/l. The bottom layer of the lake will not become anaerobic but will reach very low dissolved oxygen (DO) levels of the order 2 mg/l.

2. Forecast year 2000 discharges from the City STP and Spokane Valley STP with secondary treatment and phosphorus removal will result in chlor. A averaging 11 ug/l from June through August. As stratification begins to weaken in September and nutrients in the lower layers become available at the surface, chlor. A concentrations are forecast to rise to over 20 ug/l in September and to the upper twenties for a brief period in early October. The bottom layer of the lake is forecast to become anaerobic in late summer as would be expected with the small margin observed in the NPS condition. These conditions are a significant improvement over present conditions with no phosphorus removal in which the summer chlor. A concentration averages 18 ug/l. There is no significant improvement over the existing conditions immediately following turnover. There is a marked improvement over existing conditions with respect to DO. Under existing conditions anaerobic conditions are reached by mid-July in the bottom layers.

3. The simulation input was for seasonal phosphorus removal, extending from 1 May to 15 October, with no phosphorus removal from 16 October through the winter to 30 April. Simulation results indicate there would be no measurable benefit to Long Lake by year-round phosphorus removal as

compared with seasonal phosphorus removal. The simulation showns a continuing steep drop in chlor. A concentration after 15 October in the face of the sudden increase of available phosphorus, reaching concentrations comparable to NPS conditions by the first week in November. In spring, there is no chlor. A production through April despite abundant phosphorus. Significant growth starts in May after phosphorus removal has been under way for two weeks. Temperature and light appear to be controlling factors from mid-October through April.

Performance in the years immediately following completion of the upgrading of the City STP when there are only City flows and no contribution from either North Spokane or Spokane Valley would be expected to be intermediate between the NPS simulation and the year 2000 simulation. Although the phosphorus input under these conditions would be about half of the year 2000 forecast, it appears that the discernible improvement in appearance and visible biomass activity in Long Lake would not be as dramatic as hoped for and certainly not directly proportional to the reduction in phosphorus loading.

The impact of forecast year 2000 effluent on the river itself upstream from Long Lake may also be compared with the NPS condition from the simulation outputs. Downstream from the City STP, the primary concerns are DO, bacterial quality and potential for ammonia toxicity. The low BOD inputs from the City STP appear to have relatively small impact on DO. The net BOD in the river is two to four times that at NPS conditions, with maxima of the order 4 mg/l, but DO is slightly higher due to the photosynthetic activity of algae. In the river immediately downstream from the City STP, where there is a constantly renewed supply of phosphorus, chlor. A is forecast to be in the range 30 to 40 ug/l, much higher than Long Lake. From an appearance standpoint, Nine Mile Reservoir would not be significantly improved. The improvements would probably not be visually discernible.

Test runs of two weeks duration were included in the simulation in which City STP plant performance relative to coliform removal was allowed to deteriorate to the statutory 7-day mean limit of 800 organisms per 100 ml of total coliform. Under these conditions, the simulated river conditions showed values over the 240 organism per 100 ml limit for Class A waters. When the plant was assumed to return to the statutory 30-day mean of 400 organisms per 100 ml, the river quality improved to well within Class A limits.

Test runs of two week's duration were also included to test the effect of nitrification on the potential for ammonia toxicity. During the summer season, the simulation showed that ammonia concentrations without nitrification exceed 0.3 mg/l for sustained periods. This is in excess of the criteria of 0.2 mg/l not to be exceeded at monthly mean flows as developed above in this study. With nitrification assumed in the City STP, the river quality as shown by simulation reduced the

ammonia level to less than 0.1 mg/l. The simulation is not capable of computing pH so this important factor in ammonia toxicity is unknown.

In summary, the river below the City STP as shown by simulation for year 2000 conditions will respond to Class A requirements except as noted:

1. DO will exceed minimum requirements.

2. Total coliforms will be less than maximum allowable if effluent quality is controlled to the 30-day mean limit.

3. Water temperatures will exceed 68°F[1/] during parts of the day in late summer but not due to man's activity.

4. Ammonia toxicity is a potential Class A standard violation.

5. The appearance of the water in the summer season will be strongly affected by algae in violation of Class A turbidity requirements.

Water quality downstream from a possible Spokane Valley STP is indicated by simulation of conditions above the confluence of Hangman Creek. Here an indication of the quality impact is shown by comparison between the state boundary condition and that above Hangman Creek (HC) confluence. The most dramatic impact in this reach comes not from man's activity but from the large groundwater discharge into the river between these points.

As an example, at NPS conditions in late summer, the state boundary water temperature and total dissolved solids (TDS) are 18.3°C and 41 mg/l respectively. Above the HC confluence, the temperature has been reduced to 17.0°C despite high ambient temperatures and TDS have doubled to 80 mg/l. Most of these two effects are attributable to the addition of approximately 500 cfs of groundwater with temperature of 11°C and TDS of 170 mg/l. The groundwater makes a significant addition to nitrates raising a boundary value of 0.017 mg/l to 0.250 mg/l. These changes due to groundwater are mentioned first because they are so large they tend to obscure changes due to the forecast pollutant loads.

In addition to the forecast pollutant load due to a Spokane Valley STP, the simulation includes the effect of forecast industrial loads in this same reach. As indicated in Table 9-3, the forecast industrial mass emission is about equal to the SV-STP in BOD, and total P, during the phosphorus removal season, and about one-fifth of the SV-STP nitrogen impact.

[1/] The Spokane River upper limit is set at 68°F as an exception to the general requirement of 65°F for Class A waters.

Returning to the simulation results at year 2000, the impact of the forecast pollutant load is as follows:

1. Temperature is raised approximately 0.1°C over NPS conditions.

2. DO is raised slightly due to biological activity.

3. There is negligible change in BOD.

4. Ammonia is increased by a factor of ten but is still less than 0.1 mg/l.

5. Phosphate is increased by a factor of five over NPS conditions.

6. The impact of coliform additions is not revealed in the simulation since the high boundary values appear to mask activity within the reach. There is no indicated difference over the NPS condition.

In general, it is concluded that the impact of the combined forecast industrial load and SV-STP will not prevent the waters from being Class A quality if state boundary conditions can be made to comply. The boundary waters at present are excessive in coliform count and natural water temperatures range up to 22°C, equal to 71.6°F.

Year Around Versus Seasonal Phosphorus Removal

This study demonstrates that the selection of the suggested plan is unaffected by whether seasonal or year-round phosphorus removal is required for acceptable surface water disposal. Therefore, the introduction of the issue of year-round versus seasonal phosphorus removal is not related to the fundamentals of plan selection but rather as an economic and resource concern for this element of the suggested plan.

The City is constrained to provide year-round phosphorus removal by the requirements of their waste discharge permit from DOE. This will not be physically feasible until the committed expansion and upgrade are completed in 1977. This study suggests that DOE reconsider its directive and permit the City to make a full scale trial of seasonal phosphorus removal for at least two full consecutive representative years. This suggestion is made because there is substantial evidence that seasonal removal will be equal in effectiveness to year-round phosphorus removal toward improving the trophic state of Long Lake. Starting out initially with year-round removal would preclude a test of the effectiveness of seasonal removal on the trophic status of the lake. The extremely high cost for chemicals for phosphorus removal warrants a test of feasibility for reducing the annual requirement.

The estimated annual cost for phosphorus removal chemicals on a year-round basis at the initial flow rate of 30 mgd (City only) is $550,000 at 1974 price levels. The potential initial annual saving for reduction to a removal season of 1 May through 15 October is approximately $290,000.

The fact that this cost will continue indefinitely into the future has even more serious consequences. The present worth of the difference in costs for a 20-year period as the flow increases to full plant capacity of 40 mgd is $3,700,000. The dollar cost is, of course, merely a reflection of the true energy and resource drain. This would appear to be ample incentive to perform a full scale cost-effective experiment. The cost savings cited above are for treatment chemicals only. Additional savings would accrue from the resultant reduced volume of sludge to be processed and disposed.

Among the supportive arguments for seasonal removal is the sediment composition in Long Lake. Soltero et al (1975) have shown that the sediments with high phosphorus content resulting from settling of dead aquatic organisms during the summer season are sealed by layers of silt during each spring runoff. In the opinion of the authors, this sealing may be effective against any subsequent chemical or biological action to return these phosphorus compounds to solution in lake waters. The following conclusion is quoted from the referenced study by Soltero et al (1975):

> The role that the illite clay fraction plays in the phosphorus adsorption process in the sediments of Long Lake is not fully known. The data suggested, nevertheless, that the sediment clays brought in during spring runoff may effectively seal off the sediment-water interface each year and minimize mixing and vertical migration of nutrients from the underlying sediment layers. The sharpness of the horizons in all cores support this argument.

It should be noted that Soltero's analysis of the silts laid down in the spring, although much lower in phosphorus than the summer deposits, nevertheless contain 1.5 mg/g which is significantly higher than would be found in an oligathophic lake. That is, the silt deposits, which tend to seal in the summer deposits, would also have some potential for enrichment of lower layers of lake water through chemical and biological action. The part that these silt deposits may play in the trophic condition of the lake after phosphorus removal begins at the City STP must remain a matter of conjecture until there is an opportunity to evaluate performance on a full scale.

This finding by Soltero et al indicates that every summer season may be a "new ball game" with regard to phosphorus supply from bottom deposits. Whatever happened the previous summer or winter may not contribute to the phosphorus supply in the new season by way of recycling from the benthal deposits.

Typically the spring flows of the Spokane River at Long Lake reach their annual maxima in the period April, May, June with the peak in mid-May or early June. These flows are in excess of 10,000 cfs for this 90-day period and usually reach peaks of 20,000 cfs in May. Thus each spring, on the average, Long Lake experiences an exchange rate of 12.5 days or less over a period of 90 days or an average of seven complete changes. In May the exchange rate on the average is twice as great or about once each 6 days. The actual exchange rate may be somewhat less since stratification begins in May. With such a high exchange rate in May, the carryover of water quality from the winter months will be so highly diluted that, here again, a situation exists in which there may be a "new ball game" each June starting with water quality introduced by the flowing stream in May.

Stated another way, it can be said that each June Long Lake may have no accessible memory of water quality events that took place prior to May either with regard to the stored water itself or the potential for recycling of nutrients from the bottom sediments.

There is another factor at work that lowers the capability of the lake to trap nutrients in the period between 1 November and 1 May. This is the fact that typically each year water temperatures are below 10°C for this entire period. At temperatures below 10°C the growth activity of the aquatic plants falls to very low levels, particularly since the light available for photosynthesis also is limited through most of this same period. The result is that nutrients tend to remain in solution during this period and are not fixed in the cells of organisms which can die and sink to the bottom. This would indicate that nutrients in the river from 1 November to 1 May will tend to stay in solution and be subject to the flushing and diluting actions of the high flows in May and June.

The results shown by the simulation model operating under seasonal removal conditions are simply a reflection of the two mechanisms described above: negligible biological activity 1 November to 1 May, despite large nutrient availability, and the flushing action due to high spring flows. The simulation reflects benthal conditions as they were at calibration before any phosphorus removal. Assuming Soltero et al findings are correct, the historical condition also reflects a sealing condition. Therefore, the net simulation results which indicate no significant carryover of phosphorus from the nonremoval season to the summer removal season are in keeping with the general expectation outlined without benefit of simulation.

The foregoing discussion appears to provide a good basis for expecting performance under seasonal phosphorus removal conditions not to be significantly different than with year-round removal with respect to eutrophication in Long Lake. The high degree of variation in performance of Long Lake from year to year as pointed out by Soltero et al (1975) is cause to exercise caution in interpretation of even a full scale trial. This is the reason for suggesting at least two full years of trial under seasonal removal. It is also suggested that the

monitoring of these years be comparable to the ongoing studies of Soltero et al to provide an adequate basis for comparison with historical conditions.

West Plains Wastewater Management Policy

The West Plains communities are presently relatively small and isolated from the major urban development. There are uncertainties about the growth of these communities and their individual wastewater disposal problems which combine to suggest that circumstances may develop favoring incorporation into the wastewater plan for the urban area. It is, therefore, necessary to explore these uncertainties of growth and disposal to determine if there are conditions under which combination with the urban plan would be beneficial and, if so, what impact such combination would have on the urban area plan.

The West Plains area is defined as the area west of the City including the communities of Airways Heights, Fairchild AFB, Medical Lake and Cheney. Spokane International Airport is already sewered to the City system. The area as a whole suffers from an inadequate water supply. Furthermore, the individual communities have other unique growth constraints. The AFB growth is constrained by the base mission and is forecast to have no growth. Cheney is highly dependent upon the enrollment at Eastern Washington State College and the State policy related to growth of that particular campus. Medical Lake is dependent upon the patient load at Eastern Washington State Hospital as established by State policy.

A study has been completed by Black and Veatch (1973) to provide a new water supply for the West Plains area from the Spokane Valley aquifer via a system of transmission mains. Initial steps have been taken by Spokane County to implement an augmented water supply under State Referendum 27. If implemented, it is not known what impact this will have on growth, but, presumably, with one major constraint removed it could be more than presently forecast.

All present and future development in the West Plains area faces the same wastewater disposal dilemma. They are located on the basalt aquifer and they are all in an area where the only surface streams are both small and ephemeral. These soils and surface stream conditions place severe constraints on meeting 1983 disposal conditions. Present wastewater disposal practices of the West Plains communities are of marginal adequacy. Larger populations or strict interpretation of disposal requirements could jeopardize continued operation of the existing low cost treatment and disposal facilities.

In order to evaluate the possible consequences of these communities being forced to seek more advanced disposal techniques, a number of alternatives are explored including conveyance to the City STP for treatment and disposal. It is assumed that the constraints on

formulation of alternatives is that the method of disposal must not pose a threat to the basalt aquifer and would permit secondary effluent discharge to surface waters only if there is adequate dilution or with tertiary effluent if there is inadequate dilution. With these constraints, the following alternatives are formulated:

Plan Designation	Description
AA	Conveyance of raw wastewater to the City STP.
BB	Collection to a single point for treatment and land irrigation disposal.
CC	Collection to a single point for tertiary treatment and surface streambed disposal.
DD	Collection and Conveyance to a separate secondary plant for disposal to the Spokane River.

For cost-effective analysis it is assumed that there would be adequate capacity to handle the West Plains flows in the City STP without increased expenditure for plant expansion. This is explored more fully below.

The results of cost-effective analysis and economic, social and environmental evaluation, summarized in Table 9-4, indicate that conveyance to the City STP would be a highly favored plan of action if the speculated requirements should arise.

With this indication that there may come a time when West Plains communities might seek to join the urban area plan as a beneficial solution to their problems, the treatment capacity problem of the City STP is re-examined. Based on various population forecasts the average dry weather flow from the above identified West Plains communities is found to range as follows:

Population Forecast Basis	Year 2000 Service Population	ADWF Year 2000 MGD
Per this study	22,600	2.5
Black & Veatch, moderate	33,200	3.7
Black & Veatch, rapid	57,000	6.3

TABLE 9-4

EVALUATION OF WEST PLAINS ALTERNATIVES

Plan Identifier	Description	Present Worth of Study Period Costs, 1980-2000 Millions of Dollars Capital	O&M	Total
Cost-Effectiveness				
AA	Conveyance to and treatment in City STP[1] and river disposal	5.8	1.8	7.6
BB	Collection to a single point for secondary treatment and land irrigation	11.9	1.0[2]	12.9
CC	Collection to a single point for tertiary treatment and surface streambed disposal	9.8	6.2	16.0
DD	Conveyance to a new separate secondary treatment plant[1] on the Spokane River for river disposal	8.1	2.4	10.5

Group	Weighted Ranking by Alternative AA	BB	CC	DD
Economic, Social and Environmental Ranking				
Group 1 Concerns Balanced	90.4	74.3	74.1	78.3
Group 2 Concerns Balanced	91.7	76.6	91.6	90.7
Combined Groups Weighted 75% G-1, 25% G-2	90.73	74.88	78.48	81.4
Combined Groups Weighted 90% G-1, 10% G-2	90.53	74.53	75.85	79.54

[1]Assuming seasonal phosphorus removal.
[2]Includes credit for crop revenue.

The Black & Veatch moderate growth is designated by them as "most probable" and the rapid as "remote but not unreasonalbe."

The forecast year 2000 flow for City and North Spokane combined per Plan A is 40 mgd ADWF and the nominal capacity of the expanded and upgraded City STP is 40 mgd. Thus the year 2000 forecast ADWF of the City and North Spokane together are equal to the nominal capacity of the City STP. Satisfactory operation at STP flows in excess of nominal capacity are quite feasible if the excesses are relatively small, particularly if the diurnal flow variation can be minimized through the introduction of equalizing storage. It is judged that satisfactory performance could be realized at total ADWF of up to 45 mgd if the excess 5 mgd could be delayed to the off peak hours of the basic 40 mgd by flow equalization. Flows of 42 to 43 mgd could probably be handled with no diminution of effluent quality without equalization.

It appears that flows up to the Black & Veatch moderate could be handled by the 40 mgd plant in year 2000. The impact could well be less if the population increment under improved water supply is actually a redistribution of the control population total rather than an absolute increase, since in that case there would be a partial offsetting decrease in some other tributary area.

The following conclusions are reached regarding the potential increased water supply and resultant wastewater problems for the West Plains communities:

1. The cost of providing a wastewater management system to serve West Plains communities that will provide a high level of protection to the basalt aquifer is very high. Conveyance to the City STP appears to be the least costly alternative if pressures of population growth and aquifer protection require an upgraded system.

2. The added wastewater flow potential at year 2000 from the West Plains communities ranges from 2.5 to 6.3 mgd. This range of incremental flows together with the forecast flows from the City and North Spokane are judged to be within the practical nominal capability of the expanded and upgraded City STP to year 2000. Flow equalization may be necessary to accommodate the higher range increment.

3. The costs of providing conveyance to the City STP are of the same order of magnitude as the projected costs of an augmented water supply. The proposed water supply augmentation plan could lead to the early need for corresponding improvement in wastewater disposal for the West Plains area. For this reason it is important that there be a related clarification of regulatory policy with regard to the application of wastewater discharge requirements based on expanded

growth of the West Plains communities, and that wastewater management policies in this area be closely coordinated with the water supply augmentation plan.

Spokane Valley Wastewater Management Policy

Introduction. The most pressing issue for the Spokane Valley is whether or not the area should abandon its present reliance upon individual on-site sewage disposal systems in favor of a central sewage collection and disposal system. The concern for the consequences of the exclusive use of on-site disposal in Spokane Valley to the water supplies derived from the Spokane Valley aquifer is one of long standing. Routine water quality monitoring over the years had failed to provide conclusive evidence of pollution. Despite this lack of evidence from routine monitoring, the nagging doubt persists that drainfields serving over 50,000 persons located on a highly permeable soil extending to the water table must represent a risk to the integrity of the water supply. This concern led to the sponsoring of the report now commonly referred to as the Crosby report (Crosby et al 1967). The findings of the Crosby report, although properly and conservatively qualified by the authors, were widely interpreted to mean that no drainfield leachate would ever reach the water table. The closing paragraph on the conclusions of the Crosby report is as follows:

> Whereas there is no present danger to the Spokane aquifer through drainfield operation, there must be some limit to the extent of this kind of development that can take place before problems become apparent. Prudent management of the aquifer, therefore, requires that consideration be given to sewage treatment facilities as the population density increases.

From the Crosby report in 1967 to 1973 there were no further significant investigative efforts. Routine well water quality tests continued following standard DSHS practice.

Concurrent with this study a joint program by U.S. Geological Survey and EPA addressed the condition of the aquifer from a water quality sampling standpoint using a broad spectrum of pollution parameters including many not usually analyzed by DSHS. The wells sampled were not selected specifically to detect possible effects of on-site drainfields and left several areas without sampling representation. These locational gaps were filled by a supplemental sampling program under this study employing the same broad spectrum of parameters used by USGS-EPA.

The evaluation of these data indicates that there is less than conclusive evidence of gross pollution of the aquifer from sewage source contamination. These data do indicate a measurable deterioration of water quality by comparison of groundwater quality upstream from the

metropolitan Spokane area when compared with outflow quality at Wandemere Springs as measured by key constituent parameters. These increases in constituent concentrations, while of the order of several hundred percent in some cases, do not reach levels which exceed or in any way violate current drinking water standards as established by the U.S. Public Health Service. There is inconclusive evidence that this apparent groundwater quality deterioration is solely caused by the discharge of wastes to the ground, although the suspicion that some of it, at the least, is attributable to this cause is a seemingly valid assumption. The interpretive significance of these data with regard to public health impact is further clouded by the lack of data concerning virus and the lack of clear understanding of the public health significance of complex dissolved organics which are returned to the drinking water (which has been the subject of recent EPA research and national publicity). There is also a total lack of sampling data which is specific to the surface layer of groundwater which would be expected to contain maximum concentrations of any contaminants reaching the groundwater. The masking effect of mixing of groundwater drawn from various depths in the test wells further confuses the significance of well test data.

Analysis of water quality data from conventional well water sampling provides less than conclusive evidence that on-site leachate was appearing in well withdrawals in identifiable amounts.

The data fail also to identify anomolous, but potentially critical conditions where waste concentrations and/or unusually permeable soils may permit localized groundwater pollution which may create a serious public health hazard that is not detected in the course of routine water quality examination. A clue to this potential does, however, exist in the records of groundwater quality which have documented some examples of severe groundwater pollution, the Kaiser Eastgate well data being a very dramatic example of accelerated contamination which has occurred during this study period.

The moisture deficit beneath drainfields in summer reported by Crosby et al suggested that the septic tank moisture addition was being totally removed by evapotranspiration. On the other hand, Crosby et al reported no significant salt build-up in the soil, which suggests that at some time of the year any salt accumulations are flushed downward. This evidence appeared to be contradictory regarding the ultimate fate of the drainfield effluent and its associated dissolved salts.

The apparent contradictions of moisture deficit and absence of salt build-up lead to the formulation in this study of an analytical approach to the evapotranspiration mechanism to determine a better understanding of the ultimate disposition of percolate from drainfields in the Spokane Valley. The method selected is one of analysis to compare the amount of moisture available for percolation from all sources, rainfall, irrigation and drainfield, with the evapotranspiration for the specific climate and soil conditions of Spokane Valley to determine

if there is surplus moisture available for percolation after evapotranspiration losses.

Results of the Analysis of Evapotranspiration and Recharge. The special analysis of the evapotranspiration and recharge mechanisms applied to Spokane Valley was prepared for this study by David K. Todd, Professor of Civil Engineering, University of California, Berkeley. The results reported below are derived from that study.

An analysis of the evapotranspiration and groundwater recharge mechanisms for urban and suburban land use conditions in the Spokane Valley indicates that a significant proportion of the leachate from septic tank drainfields is available for percolation to the water table. The analysis of soil moisture behavior is based on a conservative interpretation of data and a conservative application of soil moisture transport technology. Notwithstanding the conservative approach, the analytical results indicate a net surplus of leachate and precipitation available for percolation to groundwater. This analysis concludes that there is, as a result of the indicated percolation of septic tank effluent and other applied surface waters, an accumulation of these percolated flows joining the surface of the groundwater as it progresses westerly through the valley. The estimated quantity of leachate and precipitation recharge reaching the groundwater is sufficient to transport all of the soluble salts downward with no accumulation in the soil.

Further analysis indicates that the soil moisture content required to account for the vertical transport of the calculated volume of leachate is an increment above field capacity so small as to be almost immeasurable. A soil moisture of 8.3 percent is the estimated field capacity at which all moisture is held by capillary forces with none free for vertical migration under the force of gravity.

At a soil moisture of 9.0 percent, only 8 percent above field capacity, there is a calculated capacity for vertical transport of 0.5 inches of water per day, the approximate total application rate of a typical drainfield, undiminished by evapotranspiration. Therefore, the low soil moistures in the fall of the year, following the maximum evapotranspiration season, and absence of salt build-up observed by Crosby et al do not appear to be anomalous in the light of the analytical results.

The analytical conclusion that surface applied waters, including septic tank effluent applied to drainfields, should be reaching the water table leads to the conclusion that there should be some physical evidence of this phenomena in observed groundwater quality if the leachate has some significantly different quality parameter than the natural groundwater. The two most obvious parameters that are known to be in septic tank effluent that are not in natural groundwaters are coliform bacteria and detergents. These pollutants have not been detected in significant levels in routine mixed sampling and analyses of Spokane Valley well waters. It is widely recognized that the removal of these particular pollutants by percolation through unsaturated soil is high.

Most dissolved salts, however, are unaffected by percolation through soil and therefore should be in evidence at the water table substantially undiminished. Calculation of leachate composition indicates that the net total dissolved solids (TDS) content, considering all surface applied waters including rainfall, irrigation and drainfields, should be significantly higher than the TDS of natural groundwater as evidenced by analysis of well waters near the Idaho boundary. This fact, and the fact that the TDS parameter is commonly available from most historical samplings, lead to its selection as a possible basis for verification of the analytical results.

It must be emphasized that the selection of TDS as a verification parameter is not because it, in itself, is regarded as a significant public health concern (except at very high levels) but for its convenience and availability as an indicator. The TDS parameter is to be regarded primarily as a means of identification of the leachate and its relative abundance.

Having selected TDS as the identifier and having calculated its approximate concentration in the leachate at a level about twice that of the natural groundwater and having calculated the approximate volume of the leachate accumlating on the water table as the native groundwater flows westward through the valley, there is a basis for speculation on its probable impact on observed samples. The word speculation is intended to mean just that because of two interrelated and indeterminate factors. These factors are the degree of mixing between the leachate and the main body of natural groundwater and the degree of mixing produced by the penetration and inlet location of the wells. Depending upon the degree of mixing postulated for each, the observed quality could range from all leachate of the order 300 mg/l TDS to all natural groundwater at approximately 150 mg/l TDS. If any mixing at all is taking place by either mechanism, the observed trend should be a gradual increase in TDS in an east to west direction as the moving surface of the water table is impacted by successive increments of leachate. There is some evidence from well data that such a trend does exist but there are anomalies in the evidence that prevent drawing a firm conclusion that the analysis is absolutely proven by field data. A specific sampling program addressed to meeting the inadequacies of the existing data is suggested.

Thus, at this point in time, the basis for making a policy decision regarding on-site disposal in Spokane Valley remains without absolutely irrefutable evidence either that there is or is not:

1. A present danger to public health.

2. A future danger to public health.

3. A present irreversible degradation of water quality, other than health concerns.

4. A future irreversible degradation of water quality, other than health concerns.

The most significant change in evidence over that which existed prior to this study is the analytical result which demonstrates that leachate from surface applied waters including septic tank drainfields are probably reaching the water table of the Spokane Valley aquifer in significant quantities. The public health and long-term water quality implications of this link are the remaining but all important unknowns. The conclusion of Dr. Todd which established the probability that there is wastewater recharge of groundwater as it passes through Spokane Valley, which is supported by the data collected by Crosby et al, identifies a linkage between a major waste source and the potable water supply serving the total metropolitan Spokane area. It is considered that this identified lingkage, although influenced by physical dilution of considerable magnitude, constitutes a risk to public health of unknown severity.

Background for the Decision Process. In order to arrive at an appropriate decision regarding wastewater management in the Spokane Valley area, it is important to summarize some fundamental elements which provide the basis for a planning decision at this time. The lack of conclusive or irrefutable evidence, which might make the decisionmaking process an automatic technical consideration only, has been previously cited. This circumstance should not be construed as a convenient excuse for making no decision at all or a decision to defer adoption of wastewater management policy indefinitely while continuing to look at the situation to see what develops on the assumption that improved data will render the decisionmaking process less difficult. The fact is that there is a considerable amount of data which has been analyzed and there is considerable substance to the work which has been performed by investigators such as Crosby et al and Todd. To be considered also is the precedence reflected in well-established philosophies of public health which recognize the merit of conservative regulatory public health policies, based on long experience, which emphasize prevention where an identified risk is observed.

Consideration should also be given the traditional urbanizing evolution of communities wherein there is a need to functionally improve methods for wastewater disposal in order to accommodate the demands for more intensified and variable land use. This important consideration raises a decisionmaking issue which is almost totally independent of the issue of groundwater quality impact and is one which ultimately may become the primary governing issue concerning wastewater facilities decisions in Spokane Valley.

Regulatory Requirements. The development of regulations pertaining to protection of the environmental quality of groundwater to date has not received comparable attention as the concern for the quality of surface water. Minimum standards for the quality of drinking water have been established by the U.S. Public Health Service (PHS) since 1962. The recently enacted Safe Drinking Water Act (PL 93-523) will be administered by EPA, which is in the process of establishing standards which

will augment the 1962 U.S. PHS standards. These new guidelines will not be formalized or become effective until December 1976 and until that time the exact impact on water management policies will not be known. The new Safe Drinking Water Act will expand the existing specifications for maximum contaminant levels for inorganic chemicals contained in the present U.S. PHS standards and will establish new standards for total organic chemicals, pesticides, turbidity and microbiological contaminants. The act also provides for strict protection of the quality of sole source groundwater aquifers.

Present EPA standards require that the groundwater resulting from the land application of wastewater shall meet current U.S. PHS drinking water standards.

Policy Resolution by Regulatory Action. It is considered reasonable to expect that the policy regarding on-site disposal should be resolved by regulatory action. There are four regulatory agencies with jurisdiction which could act: EPA, DOE, DSHS and the Spokane County Health District (SCHD).

Under PL 93-523 a new regulatory responsibility is placed on EPA which includes provisions for delegation to the states, presumably involving DOE. Under Part C of PL 93-523, it is proposed to regulate, through a permit system from the states, all subsurface disposals except individual septic tank drainfields. Facilities serving multiple dwellings would be covered. Guidelines are in the process of preparation and release. An interim provision, available for action at this time, concerns protection of sole source aquifers. An individual or community can petition EPA to designate an aquifer as a sole source potable water supply whose protection is vital. If EPA finds that the aquifer qualifies for designation as sole source, EPA then has interim powers to prohibit any new subsurface disposal on that aquifer until regulation is taken over by the State. The prohibition of new subsurface disposals is contingent upon a finding by EPA that the new disposal has potential for degradation of the aquifer. Degradation itself does not have to be proven, only the potential must be established. This control does not extend directly to individual septic tanks but does indirectly through the provision that all Federally funded projects must obtain certification from EPA that their implementation would not be a potential danger to the sole source aquifer. Thus, an FHA loan would be contingent upon EPA approval of the disposal system. It is anticipated that EPA will find that the Spokane Valley aquifer qualifies for designation as a sole source. Under these conditions, EPA and eventually the state (DOE) would be faced with the decision of determining if the addition of more septic tank drainfields constituted a potential for degradation of a sole source aquifer.

Policy Options. As previously stated, there is a need for a policy decision regarding on-site wastewater disposal in Spokane Valley whether it be made by a regulatory agency or by local political entities, particularly Spokane County. Of course, one of the alternatives open to policy makers is to make no decision now, to wait and

see. This can be as unfair and shortsighted as any arbitrary decision to take unfounded action. It is intended to define and explore the options open to decisionmakers in the face of a lack of absolute scientific evidence for guidance and to develop a basis for selection of a suggested plan.

The basic Spokane Valley wastewater policy options are as follows:

1. Make no policy decision regarding on-site disposal and no interim policy for guidance of land use planning.

2. Adopt a wait-and-see policy, postponing final policy, but formulating an interim policy with regard to land use planning.

3. Adopt a policy that on-site disposal may continue indefinitely and should constitute no constraint on land use.

4. Adopt a policy that foresees the ultimate need for phasing out on-site disposal in favor of community sewers, formulates land use policies oriented toward ultimate use of community sewers and provides for a staged plan of implementation.

Before attempting to make a selection from these basic options or trying to formulate the many subalternatives that are associated with all except the no action plan, certain other questions suggest themselves as necessary background:

1. Are there available practical scientific methods that have not been utilized that would provide a definitive answer to evaluate the present health threat of existing on-site disposal?

2. What philosophy has been adopted by other regulatory agencies faced with similar problems, and what are the areas of incomplete knowledge that cause these problems to be widespread?

3. What are the possible risks inherent in continuing on-site disposal if on-site disposal is having some presently undetectible degrading effect?

4. Is there presently available or is there a reasonable prospect for an alternative to the septic tank and drainfield?

5. Are there criteria for the maximum number or density of on-site disposal which are considered safe? Are there locations at which future development with on-site disposal could take place with minimum risk?

6. Are there other acceptable alternatives to protection of the potable water supply other than removing the risk due to percolation from on-site disposal?

Prospects of Further Testing. The Todd analysis postulates a layer of leachate traveling on or mixed with the top layer of natural groundwater. Sampling to date from large pumped wells probably has not produced a concentrated sample from these surface layers. If a sampling program were implemented to achieve adequate sampling of the surface layers what could be expected to be learned from it? If enough samples were taken to be statistically valid, it is probable that a trend of increasing TDS with exposure to drainfields would be verified. It is also possible that higher concentrations of nitrate and chlorides from the upper layers downward would further confirm the linkage between the drainfield leachate and the water table. It would be desirable to test for virus in the event that virus testing techniques may be improved to a point which would permit routine analysis. Although bacteria are subject to a high degree of removal from wastewater traveling through the unsaturated soil zone, it is desirable to extend the scope of coliform monitoring, particularly during extreme conditions of precipitation and high groundwater conditions to determine the extent of coliform migration under saturated or near-saturated conditions. Testing of all parameters should be intensified during these extreme conditions.

There is no assurance that selective sampling of surface layers for more parameters might not raise more questions regarding the suitability of the potable supply. There are uncertainties regarding the occurrence and significance of inorganic and organic chemical pollutants (Kaufman 1974). Although there is laboratory evidence that virus removal by soil percolation is good (Drewry and Eliassen, 1968), the confirmation of their elimination in the field is hampered by the lack of a satisfactory standard test (De Michele et al, 1974). In addition there are other areas of uncertainty regarding the public health consequences of ingestion of reclaimed wastewaters as discussed below. These areas of uncertainty make it impossible to say that further testing would remove all doubts as to which path of action should be taken.

Risk of Irreversible Damages. For most groundwater basins which have a negligible or small flow-through and which are substantially static, the risk of irreversible water quality damage by wastewater percolation is so high as to be almost a certainty. The Spokane Valley with its unusual geologic conditions and very large flow-through presents a lower risk of irreversible damage than is typically encountered elsewhere. The generalized condition is subject to the impact of increased groundwater withdrawals anticipated, particularly as may result from projects such as the Rathdrum Prairie groundwater development project. Major groundwater withdrawals significantly impact the groundwater gradient and may materially influence the groundwater flow pattern. It should also be recognized that there are unknown localized geological conditions which could restrict the flushing action of groundwater flow in such a way as to provide the opportunity where contamination could locally persist for longer periods.

Health Risk Evaluation. A concise summary of the uncertainties surrounding the ingestion of reclaimed sewage wastewaters is contained in a policy position paper[1/] developed by the State of California which is quoted below:

> Health risks from the use of renovated wastewater may arise from pathogenic organisms and toxic chemicals. The nature of the phenomenon associated with pathogens and heavy-metal toxicants are well enough understood to permit setting limits and creating treatment control systems. This is not the case, however, with regard to some organic constituents of wastewater. In particular, the ingestion of water reclaimed from sewage may produce long-term health effects associated with the stable organic materials which remain after treatment.
>
> This is an area of unknowns-unknowns involving the composition organic materials, the types of long-term effects, synergistic effects, metabolite formations, treatment effects, methods of detection and identification, and ultimately, the levels at which long-term health effects are exerted.
>
> The urgent need for knowledge in this area has generated increased calls for answers by health authorities, the water industry, resource managers, and the scientific community. It now appears that the need for research is recognized and there should be action in the near future. As a suggestion of the time frame needed for research activity, it has been estimated that the interval needed before information can be generated through animal feeding experiments (one possible method of study) could range from six to ten years or longer depending on the results that are obtained. The health effects of concern are not immediate or acute. They are related to ingestion over an extended period, measured in years or decades, and may be serious but quite subtle.
>
> In summary, stable organics pose a health question when reclaimed water is used to augment a domestic water supply. This question will not be answered for years, and years of exposure may be involved for the occurrence of adverse effects.

The foregoing quotation is addressed specifically to situations where reclaimed wastewaters are to become a significant part of a water supply to be used for human ingestion including the situation in which the reclaimed wastewater reaches the water table after percolation through overlying soils. The Spokane Valley situation meets this description, the only question being whether the leachate from septic

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1/ "Position on Basin Plan Proposals for Reclaimed Water Uses Involving Ingestion" prepared as guidelines for State of California Department of Health.

tank drainfields becomes a "significant part" of the water supply. In regard to defining "significant part," the referenced position paper states:

> The application of limits on specific percentages of reclaimed water allowable in groundwater would be inappropriate because knowledge of health effects is lacking.

The position paper recommends against near-term (that is present or near future) recharge of reclaimed sewage by percolation where the volume of recharge is large and the receiving basin small. For the situation where the recharge would represent a small proportion of the groundwater volume, the referenced position paper states that it may be acceptable but with the qualification that:

> . . . .Location relative to community wells will be considered as well as the domestic use of the basin waters.

In summary, the state of the art with regard to defining the risks associated with ingestion of reclaimed wastewaters reaching the water supply via soil percolation is such that a more definitive answer is not expected in the immediate future.

Because of the various uncertainties and anomalous conditions cited above which hamper a precise and clear scientific understanding of the many implications of continued discharge of wastewater to permeable soils overlying the Spokane aquifer, it is considered that it is prudent and in keeping with basic public health philosophy to establish a more conservative policy with regard to continuance of this practice on a large scale.

<u>Alternatives to the Septic Tank and Drainfield</u>. The State of Oregon Department of Environmental Quality recently commissioned a study of the available alternatives for individual and small group sewage treatment (Brown and Caldwell, 1975). This report concludes, with regard to individual disposal, that there is not now, nor does there appear to be any prospect for, a "black box" treatment facility that will realistically eliminate the need to dispose of wastewater from a conventional residence by percolation or that will remove all concern for the quality of that effluent. This study found, for urbanizing areas where the residences are served by running water, only one acceptable alternative to the septic tank and drainfield, namely mechanical oxidation and drainfield. This alternative is presently used in Spokane Valley for multiple units and other larger dischargers. The treatment provided by these mechanical systems, when well operated, is superior to septic tanks in BOD and suspended solids removal but there is no known difference in the quality of the effluent with respect to parameters discussed above relative to public health concerns. The justification of these systems is based on the fact that they encourage development of community sewerage systems at the time of initial development of the land when collection sewers can be built with a minimum of cost and disruption to roads and other utilities and at a time which is most convenient financially.

The geography of development in Spokane Valley indicates that the sites available for significant unit development are remote from the river and the only available disposal is to a drainfield until such time as a community sewer system is extended to these sites. Because of the long trunk sewer required to serve these areas, interim facilities for treatment and disposal to surface water are not economically feasible for much of the developing area of Spokane Valley.

Criteria for Density, Number or Location of On-site Units. The state of the art indicates that criteria cannot be established at this time in terms of allowable quantities of reclaimed wastewaters or their constituents that can make up a potable water supply. This indicates that criteria cannot be set in terms of either the density or the absolute number of on-site facilities that are acceptable. In the case of Spokane Valley with highly permeable soil, the practical limitation set on density by the need for percolative area and reserve drainfield sites is less restrictive than more typical areas.

The absolute number of on-site facilities along any given groundwater flow line is probably more significant in this case than the areal density. The arbitrary requirement for minimum lot size based entirely on waste disposal considerations rather than land use planning or life style requirements could have unfortunate consequences here. If, after development at low density, it is found that an unsatisfactory condition exists which can only be corrected by a collection system, the low density will have created a high cost for collection sewers.

Extreme density requirements which would essentially enforce maintenance of a rural character in the area would of course succeed in keeping the absolute number of units low also.

If it should ultimately be determined that the existing amount of development with on-site disposal is unacceptable, then higher densities would favor lower unit collection costs. This eventuality would favor location of future development as fill-in to the existing lower density development.

Selective location of future development on the floor of Spokane Valley likewise offers little prospect for reduction in risk. The entire valley floor appears to have relatively uniform percolative access to the water table. There are no flow lines passing through undeveloped areas that are significantly less likely to impact the majority of the existing wells which are in the narrowest section of the aquifer where the flow lines necessarily converge.

Other Alternatives for Protection of Water Supply. There are at least three alernatives to protection of the water supply from the risks of on-site disposal other than cessation of on-site disposal. One of these alternatives would be to provide treatment to the well water supply prior to distribution. If the sole concern were for pathogens, the treatment would consist of disinfection of each well supply. As indicated under the discussion above of the state of the art, the

precise identity of other potential hazardous substances may not be known for some time. The most likely candidate substances are organic compounds that are probably removable by carbon adsorption techniques. This type of treatment is much more costly than simple disinfection and does not lend itself to numerous installations at each well.

The second alternative is to abandon all of the present well sites downstream (groundwater flow wise) from the on-site exposure and construct new wells upstream with transmission mains to the service areas.

The third alternative is to extend all domestic supply wells to penetrate the aquifer to such depth below the surface of the saturated zone that withdrawals could be made of natural groundwater without the danger of including recharged waters from near the surface layers of the aquifer.

Each of these alternatives is technically feasible and probably less costly than any program for sewerage of the Spokane Valley. Each, however, implies abandonment of a groundwater supply to degradation. This would appear to be contrary to the spirit of PL 93-523 and probably would not be acceptable to DOE or EPA. It should be noted that the proposed guidelines for implementation of PL 93-523 define degradation of groundwater as any change in quality that makes additional treatment necessary to make the water comply with drinking water standards.

Summary of Background. The foregoing answers to the questions raised above are summarized below and are seen to offer little hope for any advantage of procrastination.

1. The criteria for water quality to meet public health requirements are subject to change and there is currently beginning an intensive investigation of the long-term effects of parameters not previously considered.

2. Further sampling and analysis of groundwaters in Spokane Valley will probably reinforce the study findings regarding the link between drainfield percolate and groundwater recharge but will not resolve the question of whether the recharge is or is not a long-term threat to public health.

3. Other regulatory agencies face the same dilemma with respect to defining the public health risks involved in recycling of reclaimed sewage by percolation to groundwaters used as a public water supply. Guidance from other agencies shows adoption of a traditional conservative approach to public health concerns.

4. The Spokane aquifer with its unusually permeable soils and high rate of groundwater flow presents a lower risk of irreversible damage than is typically encountered. It must be recognized that such a generalization provides no

guarantee that damage will not occur and persist for times inconveniently long considering that the resource is used 24 hours per day, every day of the year.

5. There is no immediate prospect for an alternative to the septic tank or the mechanical aeration treatment unit, both with drainfield, for on-site disposal of wastewater from urban development. The probably impact on groundwater quality from either unit is estimated to be similar.

6. There is no basis for establishing a safe level of development with on-site disposal in terms of either density, absolute numbers or sensitive location in Spokane Valley.

7. As alternatives to elimination of on-site disposal, it would be feasible to maintain the City and Valley water supplies at prescribed drinking water standards by the addition of treatment, by relocation of the wells upstream from on-site exposure or by extending wells to deeper points of withdrawal. These alternatives are not considered as available since they imply the abandonment of a portion of a groundwater basin to degradation in violation of the intent of PL 93-523.

Formulation of Policy Alternatives. The formulation of policy alternatives relative to the use of on-site disposal in Spokane Valley must consider its application to both existing and future development and to their possible combinations. These alternatives are shown schematically in Table 9-5 and are summarized in Table 9-6. The number of combinations to be considered is simplified by deletion of certain cases which would have no practical application resulting in a reduced list as follows:

Alternative	Policy For Existing Development	Policy For Future Development
A-1	Use on-site indefinitely	Prohibited
A-2	Use on-site indefinitely	At controlled densities and locations using on-site indefinitely
A-4	Use on-site indefinitely	Uncontrolled using on-site indefinitely
B-3	Ultimately sewered	At controlled densities and locations, ultimately sewered

TABLE 9-5

ALTERNATIVE
DECISION OPTIONS FOR EXISTING AND
FUTURE DEVELOPMENT IN SPOKANE VALLEY

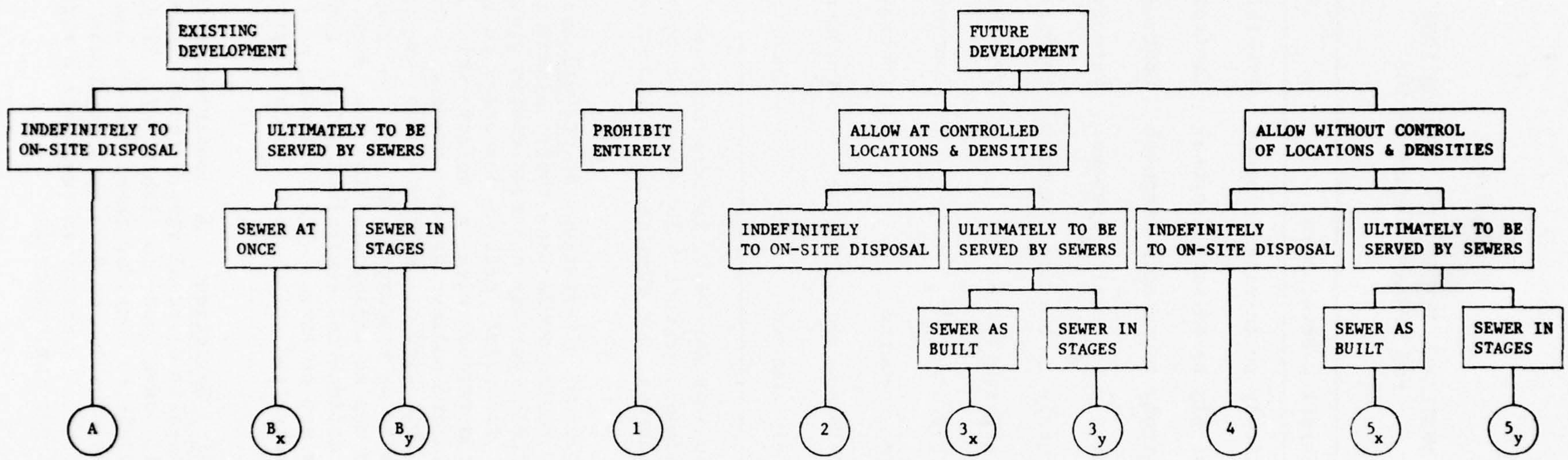


TABLE 9-6

AVAILABLE ALTERNATIVE COMBINATIONS
FOR SPOKANE VALLEY POLICY

Alternative[1]	Existing Development	Future Development
A-1	Indefinitely to on-site disposal	Prohibited
A-2	Indefinitely to on-site disposal	Controlled, on-site disposal
A-3	Indefinitely to on-site disposal	Controlled, sewered[2]
A-4	Indefinitely to on-site disposal	Uncontrolled, on-site disposal
A-5	Indefinitely to on-site disposal	Uncontrolled, sewered[2]
B-1	Ultimately sewered	Prohibited[2]
B-2	Ultimately sewered	Controlled, on-site disposal[2]
B-3	Ultimately sewered	Controlled, ult. sewered
B-4	Ultimately sewered	Uncontrolled, on-site[2]
B-5	Ultimately sewered	Uncontrolled, ult. sewered[2]

[1] Identified as shown on Figure 9-5, letters represent existing development alternatives and numbers represent future development alternatives.
[2] Impractical alternatives, not considered in narrative discussion.

The foregoing represent alternatives of defined and recognized policy upon which the County would base their planning action, including processing of building permits and subdivision plats, as well as any institutional or financial actions necessary to implement the policy. This is to be contrasted with a policy which amounts to having no defined and recognized policy as at present. The County cannot unilaterally define this kind of policy. The County can indicate their intent but unless it is concurred in by the responsible regulatory agencies it could not be implemented in the face of any opposition. The need for a defined and recognized policy appears to be widely recognized and is not at issue. The following analysis is confined to arriving at a suggested policy that can be adopted to terminate the indecision.

Rationale for Policy Selection. A comparison of the factors favoring continuation of on-site disposal versus those favoring ultimate community sewerage is developed in Table 9-7. It is the purpose of the following paragraphs to consider these factors against the background of the foregoing discussion to develop a rationale for formulation of a policy that can be suggested to responsible regulatory agencies and local governments for implementation.

TABLE 9-7

COMPARISON OF FACTORS FAVORING
ON-SITE DISPOSAL VERSUS COMMUNITY SEWERAGE

Factors Favoring Continued On-Site Disposal	Factors Favoring Ultimate Community Sewerage
1. Standard parameter testing of groundwater quality reveals no positive evidence of health hazard or significant quality degradation due to present on-site disposal.	1. Analysis of the evapotranspiration mechanism for surface applied waters including drainfield for on-site disposal establishes the recharge of the aquifer by treated wastewaters.
2. The forecast growth in Spokane Valley is proportionately small so that future impact would not be expected to be significantly different than the present.	2. The state of the art is such that the long-term public health consequences of recycled wastewaters into water supplies for human ingestion are unknown.
3. The costs of continuing with on-site disposal are low whereas the costs of sewerage and community treatment are very high.	3. There is no present alternative to the septic tank for on-site disposal and little prospect for a future "black box" solution to individual sewage disposal. Consequently, without sewerage, the percolate risk will continue indefinitely as long as on-site disposal is used.
4. The risk of long-term damage to the aquifer is unknown but probably low due to the large volume of flow and apparently high and uniform rate of displacement.	4. Although there appears to be a high and uniform rate of displacement in the SV aquifer, there may be local areas with much lower rates of exchange in which contamination could persist for long periods of time. In these cases the risk of long-term damage is high.
5. There are feasible alternatives to maintain a good water supply, even if the aquifer is degraded, including treatment of well supplies and relocation of wells east of the on-site disposal exposure.	5. Public Law 93-523 intends to protect sole source groundwater supplies from any degradation below drinking water quality. The fact that there is a link between drainfields and the water table exposes the aquifer to degradation from as yet unidentified contaminants.

Consider first the opposing factors regarding the identification of a threat to public health. On the one hand, routinely performed standard testing of groundwater indicates that the impact of probable wastewater recycling to the groundwater does not cause a violation of "presently recognized parameters" at levels officially considered safe for public health. Emphasis is placed on "standard testing" and "presently recognized parameters" because these elements are the focus of concern by many agencies, as exemplified by the previously quoted policy paper of the State of California. On the other hand, it is shown that there is a flow path linking on-site drainfield effluent with the water table of the Spokane Valley aquifer and that, where such a link between reclaimed wastewater and the potable supply exists, there is a potential long-term risk to public health. Two conclusions are drawn from these somewhat opposing factors: first, there probably is not an immediate critical public health exposure requiring a crash program of elimination of on-site disposal; and second, prudent evaluation of the long-term risk requires that planning specifically consider the need for replacement of on-site disposal by a collection system. The first conclusion is reinforced by the apparent reduced risk in this particular aquifer to long-term damage because of the relatively high rate of displacement. The later conclusion is reinforced by the fact that there is no present or foreseeable alternative type of on-site disposal that would remove the risk inherent in present septic tank or mechanically aerated treatment systems with drainfield disposal. It is further reinforced, perhaps decisively, by the national policy for protection of sole source aquifers as indicated by the provisions of Public Law 93-523.

The fact that the forecast growth in population of Spokane Valley is a relatively small proportion of the present population (approximately 30 percent to year 2000) tends to minimize the potential for a sudden catastrophic deterioration under continuing on-site disposal policy but could, without planning, significantly aggravate the problem of providing a collection system when needed. The present development is badly scattered, particularly in the older areas which developed along section and subsection lines, presenting a costly configuration to join with a collection system. Future development, if encouraged at moderately low density at and beyond the fringes of present development, will increase this problem, whereas fill-in development could provide significant reductions in costs per unit served. The fact that there appears to be no potential reduction in pollutional threat from on-site disposal in Spokane Valley based on selection of perferred locations or densities indicates that there is more to be gained by planning for future ease of collection than by striving for doubtful gains from low density or restriction of development to specific locations.

There are national trends strongly toward multiple unit housing. This trend is less pronounced in Spokane but significant. The desirability of fill-in development from a future sewerage standpoint and the trend to multiple unit dwellings is compatible and suggests fostering of incremental sewerage plans serving such development where desirable from an overall planning standpoint.

It is most desirable that sewage disposal not be the sole criterion for land use planning or that it not be used as a weapon to force particular kinds of land use planning that proponents feel they can enforce only by this subterfuge. Ideally land use planning should be based on the overall maximization of social, economic and environmental benefits. The foregoing suggestions for consideration of sewerage problems in the immediate future of land use planning in Spokane Valley is made reluctantly as a violation of these principles. The present situation, however, exists in part from lack of planning and the sooner the waste disposal problem is solved, the sooner land use planning should be free of it as a primary constraint.

In terms of the alternatives developed here, this rationale indicates that Alternative B-3 is the most desirable response. This alternative provides for ultimately sewering both existing and future development. Based on this fundamental consideration, a suggested policy and plan is presented below.

Suggested Policy. The first suggestion is support of an accepted policy, whether it be as proposed herein or another alternative. The complexity of the problem and its importance to local government deserve a formal resolution. It is suggested that DOE take the lead in convening a groundwater quality policy commission for this purpose with representation from DOE, EPA, DSHS and SCHD. In addition to the testimony of this study, the commission may wish to utilize a technical advisory board of experts. The most important charge to the commission should be that it must reach a conclusion and present an acceptable policy that will stand for the use of local government, freeing this matter from the vicissitudes of political pressure.

It is suggested that the policy for Spokane Valley development recognize the ultimate need for a community sewage collection system and the ultimate phasing out of on-site disposal except at rural densities. The judgmental basis for this conclusion is the established percolate link between drainfield effluent and the water table, the inherent risk involved in such a link with the sole-source drinking water supply and that continuance of this practice will be in conflict with emerging national groundwater quality control policies.

The implementation of a policy calling for ultimate sewerage of Spokane Valley must consider the constraints of the existing pattern of development, the forecast growth, land use planning compatible with the desired life-style and financial feasibility and fairness. The existing pattern of development, especially in the older developed areas, is scattered and costly to sewer. Planning should encourage fill-in development over opening of new areas on the fringes of existing development. Lot size restrictions should be governed by the life-style requirements rather than an attempt to reduce on-site impact through excessively large lots. Financial feasibility suggests stage construction but fairness requires a widespread sharing of the costs which, while directly benefitting a few at first, represents a step toward solution of an area-wide problem.

Specifically, it is suggested that continuation of development be allowed using individual on-site disposal licensed for a limited time period and with option for renewal by the governing agency. This development with suburban lot sizes would be restricted to essentially the existing built-up area. Beyond the built-up area, development would be restricted to rural densities of about 5-10 acre minimum until such time as the contiguous developed area is served by community sewers. After that time, higher development should be considered if desirable from a planning standpoint.

Further, it is suggested that a commitment be made to a stepwise implementation plan of sewerage and surface water disposal as proposed for Spokane Valley under Plan A. It is suggested that the initial sewerage system be selected to provide service to the commercial, multiple unit and high density corridor.

It is suggested that the initial increment of such a staged implementation plan be based on the recognized critical need for collection of wastewater from the industrial, commercial and high density multiple residential area which exists along a corridor which would be served by the Sprague Avenue, Mission Avenue and Millwood trunk sewers, with possible consideration of extension of the corridor along Mica-Dishman Road. This program recognizes the need associated with the intensified land use along this corridor and also recognizes the reality that it is unlikely that an initial implementation of a sewerage program for the total Spokane Valley would gain sufficient public support. The "corridor plan" would provide the "backbone" of a valley system which would permit extension into adjoining areas as both need and public support develop. Such a plan should also encourage fill-in development within the existing urbanizing area of Spokane Valley.

The "corridor plan" concept is further supported by the fact that the Spokane Valley aquifer is particularly vulnerable to contamination from dissolved salts, such as the salts of toxic heavy metals, and to organic chemicals, both of which are used in many types of industry. Refer to the two incidents reported by Esvelt and Saxton (1964) and the recent Kaiser Eastgate well problem for examples of this vulnerability. For this reason, the location of industries with known use of these classes of chemicals on the surface of the aquifer constitute a risk by their very presence. A spill of toxic or organic chemicals or their leakage from sewers or holding ponds could be disastrous. A large leak in a service station gasoline storage tank could also be a serious problem. It is suggested that chemical use and storage be considered in future applications for industrial locations on the surface of the Spokane Valley aquifer and that a policy be defined to screen such application. Refer to discussions of these considerations and case histories of groundwater spills in "Ground Water Contamination in the Northeast States" by Miller, DeLuca and Tessier (June 1974).

Summary of Wastewater Management Plan Suggestions

Both cost-effective analysis and evaluation of economic, social and environmental considerations point to the suggested plan to combine North Spokane and the City to the committed City STP expansion and provide separately for Spokane Valley. This plan, designated Plan A in the formulation and selection process, has flexibility to meet two important areas of uncertainty, namely the future upgrading of standards to meet 1985 goals of PL 92-500 and the action to be taken with respect to on-site disposal in Spokane Valley.

The foreseeable alternative responses to interpreted criteria to comply with 1985 goals involve ultilization of and additions to the facilities which will result from the committed City STP expansion. Therefore, future compliance with interpreted 1985 standards by any of the three most probable alternatives will not involve wasting any major part of the facilities proposed for Plan A. If surface water disposal is selected for 1985 conditions, it would mean the addition of advance physical-chemical processes to the committed City STP with continued utilization of all facilities with the possible exception of the chlorination equipment which may have to be replaced by ozonation or supplemented by dechlorination facilities. If infiltration-percolation disposal is selected, the committed City STP would remain in service as the essential pretreatment with the only equipment disused being that for phosphorus removal; and, a possible addition would be nitrification-denitrification facilities if future groundwater standards so dictate. If land application is selected for 1985 conditions, the committed STP would remain in service as the essential pretreatment, and, as for infiltration-percolation, with only the phosphorus removal facilities disused.

In the case of the Spokane Valley, where the required secondary treatment plant is a future cost rather than a sunk cost, the reasoning is the same with respect to future utilization of these facilities for all alternatives to comply with interpreted 1985 standards. Note that separate facilities for Spokane Valley are most cost-effective for disposal with 1985 standards as well as with 1983 standards for any given disposal alternative. This means that there would be no incentive to abandon a separate Spokane Valley facility in favor of combining with the City due to the need to comply with 1985 standards.

The uncertainty of the timing of implementation for Spokane Valley as an element of an integrated system would necessarily make the implementation of a total unified system uncertain. Plan A calls for Spokane Valley as a separate plan element so that the City-North Spokane subsystem may be independent of the uncertainties concerning implementation of the Spokane Valley element. Evaluation of Plan A shows that there is no technical or financial justification for the elements to be combined.

Since the surface water disposal solutions of Plan A for both elements are stepping stones to the more costly infiltration-percolation and land application alternatives, Plan A is the ideal pragmatic approach to these advanced techniques. It is only reasonable to initially implement the lowest cost alternative if that lowest cost plan increment is a required element of the more costly alternatives whose need is not immediate.

Water quality performance of Plan A is good, although it may not satisfy some who hope to see absolutely no evidence of man's impact upon the Spokane River. The point of diminishing returns will have been reached relative to surface water disposal with implementation of secondary treatment and phosphorus removal. The quality of Long Lake, which is itself an unnatural feature of the environment, is demonstrated to be less than ideal even under NPS discharge conditions. The high temperature of the Spokane River as it enters the study area and the low flows of late summer and fall are natural obstacles that defeat further improvement without complete diversion of wastewater flows to some form of land application. The high cost of upgrading to land application must be weighted against the value to the community of some of these less-than-ideal but acceptable conditions. What is the value of further reductions in algal production in Long Lake once less-than-nuisance levels are reached, recognizing that no degree of removal can prevent strong stratification in summer with consequent excessively warm surface layers and bottom layers devoid of oxygen, neither of which are ideal for certain preferred types of fish? This is a question that the community should answer, but probably not even ask itself, until the new treatment facilities now under construction are tried and results can be observed full scale.

The simulation strongly suggests that seasonal phosphorus removal should provide all the benefits of full time phosphorus removal at about half the cost. It is suggested that the City seek permission to try seasonal phosphorus removal first, rather than year-round removal. The amount of money involved suggests this as the prudent approach since full-time removal will not provide proof of whether the seasonal approach is valid.

The findings on potential ammonia toxicity do not call for precipitate consideration of major structural additions to accomplish nitrification or denitrification. Ammonia toxicity is not well defined as yet. Bioassay tests, with the specific fish and waters at the temperatures and pH conditions found in the Spokane River, are required after the improved plant is in operation long enough for fish to re-establish themselves. It is suggested that experiments be carried out when the plant is completed to determine the degree of nitrification that can be achieved by unloading the activated sludge reactor by moving the chemical precipitation for phosphorus removal to the primary. This would undoubtedly create some operational problems in sludge processing, but it offers a low cost method for short time reduction of ammonia output that should be explored before consideration is given to

higher cost alternatives. There is time to solve this problem in early years before growth brings the loading to critical levels.

Plan A is suggested for selection as the primary plan for the many evaluation factors in its favor, including most favorable ranking in cost-effectiveness and economic, social and environmental screening, flexibility to meet future changes in disposal criteria, flexibility to meet Spokane Valley needs and full utilization of a State and Federally funded regional wastewater treatment facility.

In view of the concern that adequate consideration be given to land application alternatives and particularly to irrigation, it is well to summarize the specific conditions facing utilization of reclaimed wastewater for irrigation in the Spokane area. There are several factors uniquely unfavorable to land application by irrigation in the Spokane area. On a regional basis natural water resources are plentiful and relatively unutilized. The surface waters of the Spokane River are unused except for nonconsumptive power generation and cooling. It is true that the Little Spokane Valley has had irrigation withdrawals curtailed and that the West Plains area has no significant local water supply, but both of these areas could be supplied with water from existing sources if the necessary pumping transmission and storage facilities are provided. It is the cost of delivering the water rather than the availability of the water that prevents these areas from being supplied. Essentially the same physical facilities would be required to deliver reclaimed wastewater to these areas as are required to deliver existing available natural water.

Another factor unfavorable to irrigation with reclaimed wastewater in this specific case is the elevation at which it becomes available and the elevation at which it is usable for irrigation. The City STP discharges at an elevation of 1689. Regardless of the specific site chosen for irrigation, all feasible sites are in the range of 2000 to 2400 feet elevation. This large static lift, together with the friction losses for conveyance to remote locations, represents a large energy requirement. On the other hand, these wastewaters would produce energy if discharged to surface waters to fall through a total of 402 feet at Nine Mile, Long Lake and Little Falls power houses. The net energy cost would be the same to pump the same quantity of new water out of the Spokane River to storage during high flows as it would be to pump reclaimed water to storage year-round. If the primary objective is to provide irrigation waters, it would cost less to pump natural water as needed and avoid the potential health, odor and other problems associated with reclaimed wastewaters. New waters supplied for irrigation do not raise any questions about land ownership or contractual agreements limiting the operations on the land as would reclaimed wastewater irrigation.

The soil, crop and climate conditions also mitigate against reclaimed wastewater use for irrigation. If wastewater disposal is the primary objective, lowest disposal costs is a primary goal. Lowest cost is

achieved by the highest possible reclaimed wastewater application rates on the smallest possible areas. The most prevalent cash crops in the area are wheat and other small grains which cannot use or tolerate large quantities of water. High application rates mean a change in crop to something like alfalfa. If water at low cost were made available to farmers on the basis that they only had to take what they needed to maximize their production of wheat, they would take about 12 inches per year. This would double or triple the area for which distribution facilities would be required over those that would be required where disposal is the goal rather than crop production. In areas like the Williams Valley, where forage crops are more attractive, the short growing season is a limiting factor.

The incremental increase in crop value that can be obtained through irrigation is too small to pay the cost of transporting and distributing water to the deficient areas. If water were made available free at the corner of a wheat field, the owner could afford to use it. If he were required to pay any significant portion of the capital recovery costs for transport of 10 miles or more and a lift of 300 to 700 feet and seasonal storage, he could not afford it. This means that irrigation use of reclaimed wastewater cannot be justified on the basis of net economic gain for the area. The higher costs for irrigation application of wastewater must be recognized as such; as a higher net cost for disposal over alternative means and not as a hidden subsidy for increased economic output.

The committed upgrade and expansion of the City STP includes facilities for sludge disposal by anaerobic digestion, vacuum filtration and sanitary landfill. This solids processing system, equivalent to Plan S, is shown to be the most advantageous from both a cost-effectiveness and environmental standpoint. The plan is suggested for adoption and use for an indefinite period, not only for its favored ranking but for its utility as a steppingstone and fall-back system with respect to the most likely alternatives that might prove more attractive in the future.

Land application is the sludge disposal system most likely to come into more favored consideration in the future as: (1) chemical cost increases adversely affect the conditioning costs associated with vacuum filtration, (2) fertilizer costs increase and favorably affect the use of sludge to replace chemical fertilizers, (3) space for landfill at nearby locations becomes scarce and (4) the technology of land application of sludge is better developed. The present limited knowledge of the technology of land application of sludge is the most important factor next to cost for postponing adoption of land application. It is also the reason for having an established fall-back system if and when its initial operation is begun.

Anaerobic digestion to provide a stabilized sludge is an essential element to land application and this part of the initial installation under Plan S would be fully utilized under a future land application system. The vacuum filtration facilities would provide an alternative disposal system during an initial experimental small scale trial of

land application and a long term basis for emergency operation in case of malfunction or maintenance with a fully established land application system. These alternative facilities could eliminate the need for redundancy in land application facilities which would be otherwise needed for the required degree of continuity of service.

It is less likely that incineration, drying or wet oxidation may become more favorable alternatives in the future than land application. If they were to become more favored, the Plan S facilities would again have an important role as a standby system and source of potential of operation. For the drying alternative, the vacuum filters would be completely usable as an essential element in the process. For wet oxidation, a part of the vacuum filtration capacity would be usable for last stage solids separation.

Full scale pioneering of land application of sludge for the City STP is not suggested when there is a lower cost alternative which does not foreclose its future adoption. Pilot studies are suggested to develop specific land application data for the specific conditions of soil, crops and climate of the area that could be utilized in conjunction with technology being developed elsewhere.

Plan S sludge management system is likewise found to be most favored for application to a separate treatment plant in Spokane Valley. Its adoption as the basic plan is suggested for the same reasons discussed above for the City STP. In addition, consideration is suggested for possibly delivering Spokane Valley sludge to the City STP for processing if actual full scale operation of the City STP should indicate the availability of sufficient spare capacity.

Individual Disposal Systems. Whether or not Spokane Valley implements a community sewage collection system, there will remain a significant number of on-site disposal systems throughout the study area. Many will be too remote from a future collection system to ever be feasibly connected, becoming, therefore, permanent waste disposal systems. It is desirable that these scattered individual elements of the total wastewater disposal system also be subject to management for optimum operation and protection of health. Three facets of on-site disposal require governing regulations:

1. Original construction.
2. Periodic operation inspection.
3. Disposal of septic tank pumpage.

The first and last of these items are now subject to control. A permit is required from the Spokane County Health District to construct an on-site disposal system and there are new State standards which define the quality of construction and whether on-site disposal is acceptable for the location. A permit is also required for persons engaged in pumping and cleaning septic tanks and for the disposal of the pumped

materials. The operation of the disposal sites is covered by State regulations in WAC 173-301. There are no current requirements for inspection of facilities built prior to the institution of the present permit system and no requirement for periodic inspection of both new and old systems. Also, although there are regulations specifying what kinds of disposal are acceptable for septic tank pumpage, the finding of such acceptable sites is left to the individual firms engaged in this business. There is a need for assistance in finding acceptable sites that will receive these offensive materials.

Most septic tank failures in properly selected soils are due to overflow of solids into the drainfield caused by neglect of periodic pumpage of the septic tank accumulations. Since the time between required pumpage is measured in years and there are gaps in knowledge of prior maintenance with changes in ownership or multiple dwelling situations, the occurrence of neglect is not surprising. There is a management gap here to provide mandatory periodic inspections and permit renewal that should be fulfilled for the benefit of the community. The other management gap is the finding of acceptable disposal sites for pumpage.

It is suggested that this management gap be filled by local septic tank service districts, which can be either separate districts or, preferably, administered as a county or health district service.

The problem of finding acceptable disposal for the solid residue pumped from septic tanks is aggravated by the generally offensive nature of the material. It is not welcomed at sanitary landfills where the liquid should be mixed with dry materials to lower the in-place moisture content as required by state regulation. It is likewise not welcomed at the municipal sewage treatment facilities owned by other jurisdictions where it adds to the treatment load. In general, disposal to a municipal facility is environmentally the better solution and the arrangement and compensation for such disposal would be a management function that could be performed by a district or county utilities service more effectively than by individual private operators. (The management district would not preclude private operators who could still function either under contract to individuals or the district or county.)

The Suggested Plan

The foregoing consideration reinforced the selected urban area wastewater management plan and lead to the following suggestions.

1. Adoption of Plan A by the City of Spokane and Spokane County as the sewerage general plan which will most effectively meet the water pollution control needs of the metropolitan Spokane area based on compliance with the 1983 criteria set forth in the PL 92-500 guidelines. Adoption of Plan A would constitute a commitment to support the following specific planning concepts:

a. Provide wastewater treatment at the existing City STP (upgraded) for both the City and North Spokane Valley areas.

b. Provide a separate treatment facility near Felts Field to serve the Spokane Valley service area.

c. Operate both facilities with effluent disposal to surface waters.

2. Adoption of a future contingency plan to upgrade Plan A to meet the possibility of future more stringent requirements interpreted to meet 1985 goals of PL 92-500. The suggested upgrade plan, designated Plan D in this study, is a plan to add land disposal by rapid percolation to the pre-existing Plan A facilities.

   a. Reservation of necessary rapid percolation sites for both the City-North Spokane subsystem and the Spokane Valley subsystem assuring the future availability of the sites through zoning or purchase alternatives.

3. Implementation of an inter-local cooperation agreement between the City and County to provide the institutional and financial resources to plan, manage and fund the suggested unified subsystem under Plan A for the City and North Spokane service areas. (Refer to Section 10 for development of the institutional and financial suggestion.)

4. Assumption by the County of the institutional and financial responsibilities for implementation of the community sewerage facilities suggested under Plan A for the Spokane Valley service area.

5. Consideration be given to revising the discharge permit for the upgraded City STP to provide for full scale evaluation of the feasibility of seasonal phosphorus removal through trial operation for at least two consecutive representative years.

6. Utilization for an indefinite period of the sludge processing and disposal system being provided in the committed upgrade of the City STP, namely anaerobic digestion, vacuum filtration and truck haul to sanitary landfill.

   a. Formulation of a specific plan for data gathering through pilot operation directed toward specific evaluation of criteria for land application of sludge using local soils and crops.

b. Establishment of a program to update from time to time the potential for land application as an alternative sludge disposal method as effected by changing technology and costs of fertilizer chemicals.

7. Adoption of a planning policy that recognizes the desirability and benefits of ultimately phasing out on-site sewage disposal in the urbanizing area of Spokane Valley in favor of a community sewerage collection and disposal system leading to the eventual implementation of Plan A as applicable to the Spokane Valley service area.

a. Constitution of a commission made up of the responsible regulatory agencies concerned with water quality control and public health to generate policy with regard to on-site sewage disposal in the Spokane Valley as a firm basis for necessary planning and implementation actions by the County. The commission membership should include DOE, EPA, DSHS and SCHD.

The need for a commission is based on the fact that neither statutory guidelines nor scientific evidence will automatically provide policy regarding the relationship between on-site disposal and the Spokane Valley aquifer. Policy must derive from judgment applied to the available evidence. A uniform policy accepted and supported by all responsible regulatory agencies is essential to community action.

b. Application to EPA under provisions of PL 93-523 for classification of the Spokane aquifer as a sole source aquifer.

c. Implementation of a groundwater quality testing program as proposed in this study by David Todd directed toward sampling from the various levels of the saturated zone to evaluate the recharge waters.

d. Determination of land use planning goals for the Spokane Valley by the County giving first recognition to life style and long-range community planning goals reflecting wastewater disposal needs as indicated by the policy guidelines for the use of on-site disposal as developed by the suggested commission and adopted individually by the agencies making up that commission.

e. Implementation of community sewerage through a program of incremental construction based on the concept of initially establishing a "corridor" of sewer service along the most heavily built-up concentrations of commercial, industrial and multiple unit dwellings.

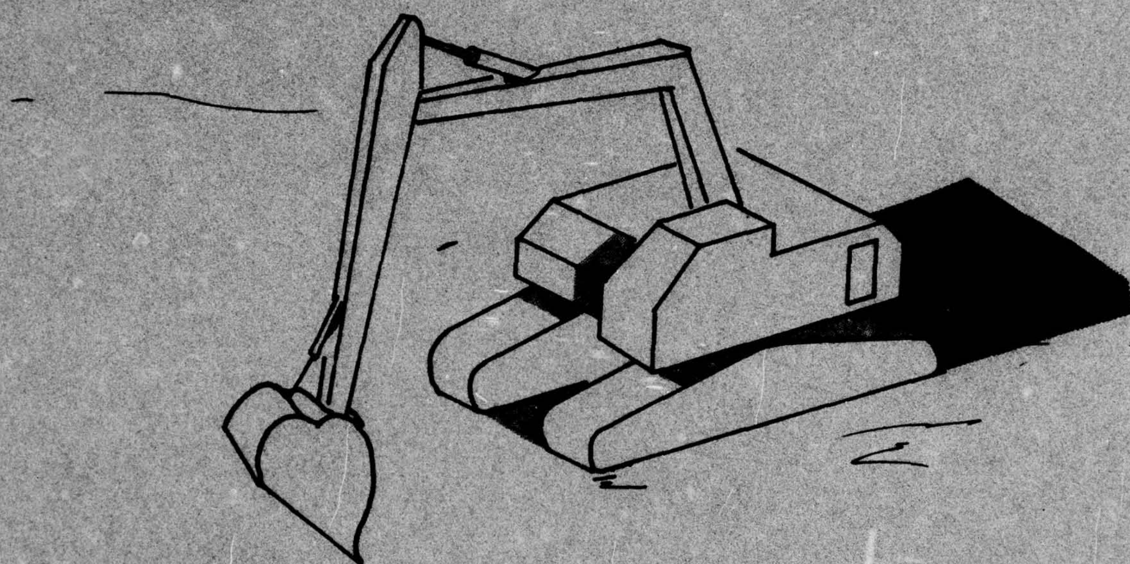
f. Adoption of a sludge treatment and disposal technology for a Spokane Valley treatment facility in accordance with Plan S for anaerobic digestion, vacuum filtration and sanitary landfill. Depending upon the timing of implementation and the status of the concurrent City facility, reconsider as an alternative disposal by conveyance to the City.

8. Implementation as adjuncts to all surface water discharges of the water quality monitoring systems required by law. Such monitoring programs should be supplemented by anticipatory programs including bioassays to forecast possible impending problems such as ammonia toxicity, heavy metals and organic compounds at the City STP as flow increases for unusual stream conditions.

9. Implementation of an aquifer-wide monitoring of the Spokane Valley aquifer by the responsible regulatory agency in conformance with the intent of PL 93-523 with emphasis on evaluation of quality as related to specific levels in the saturated layer. An early goal should be detection of the source and long-term consequences of the sudden deterioration of quality at the Kaiser Eastgate well.

10. Provision for instituting a wastewater management planning program to be undertaken for the West Plains communities if the proposed augmentation of water supply becomes a reality.

11. Implementation of a program for filling the two management gaps regarding septic tank and drainfield operation by providing for mandatory periodic inspection and by finding acceptable sites for disposal of septic tank pumpage.



SECTION 10

IMPLEMENTATION

10. Implementation

Introduction

A specific suggested wastewater management plan was presented in Section 9 for the City and North Spokane portions of the urban planning area. A decision process is proposed to arrive at a plan of action for the Spokane Valley portion of the service area. Although a major structural plan for Spokane Valley may not require early implementation as a result of the operation of the decision process, a suggested plan for that eventuality is developed. This section presents implementation plans for both.

The implementation plan consists of the following elements: a schedule, cost estimates of the required capital expenditures and forecast operation and maintenance, a suggested institutional plan and a suggested financial plan. To arrive at suggested institutional and financial plans, it is necessary to formulate and evaluate available alternatives. These processes are outlined in this section.

Schedule

An implementation schedule for the City-North Spokane portion of Plan A is shown in Table 10-1. There is an adopted County plan for the North Spokane area so that an early decision to begin implementation can be made. The schedule indicates completion of first stage construction in 1980.

There is not an adopted County plan for Spokane Valley area as required by RCW 36.94.030. Due to the uncertainties of decision and timing regarding Spokane Valley, an arbitrary but more distant starting date is selected for the implementation schedule. The selected date of decision is 1980 leading to completion of first stage construction in 1985. Table 10-2 shows an implementation schedule for Spokane Valley based on these assumptions.

Capital Cost Estimates for the City-North Spokane Subsystem

The structural features required to implement the suggested plan for serving the City and North Spokane jointly is shown in Figure 10-1. The principal elements of the system are as follows:

TABLE 10-1

IMPLEMENTATION SCHEDULE FOR
THE CITY-NORTH SPOKANE SUBSYSTEM

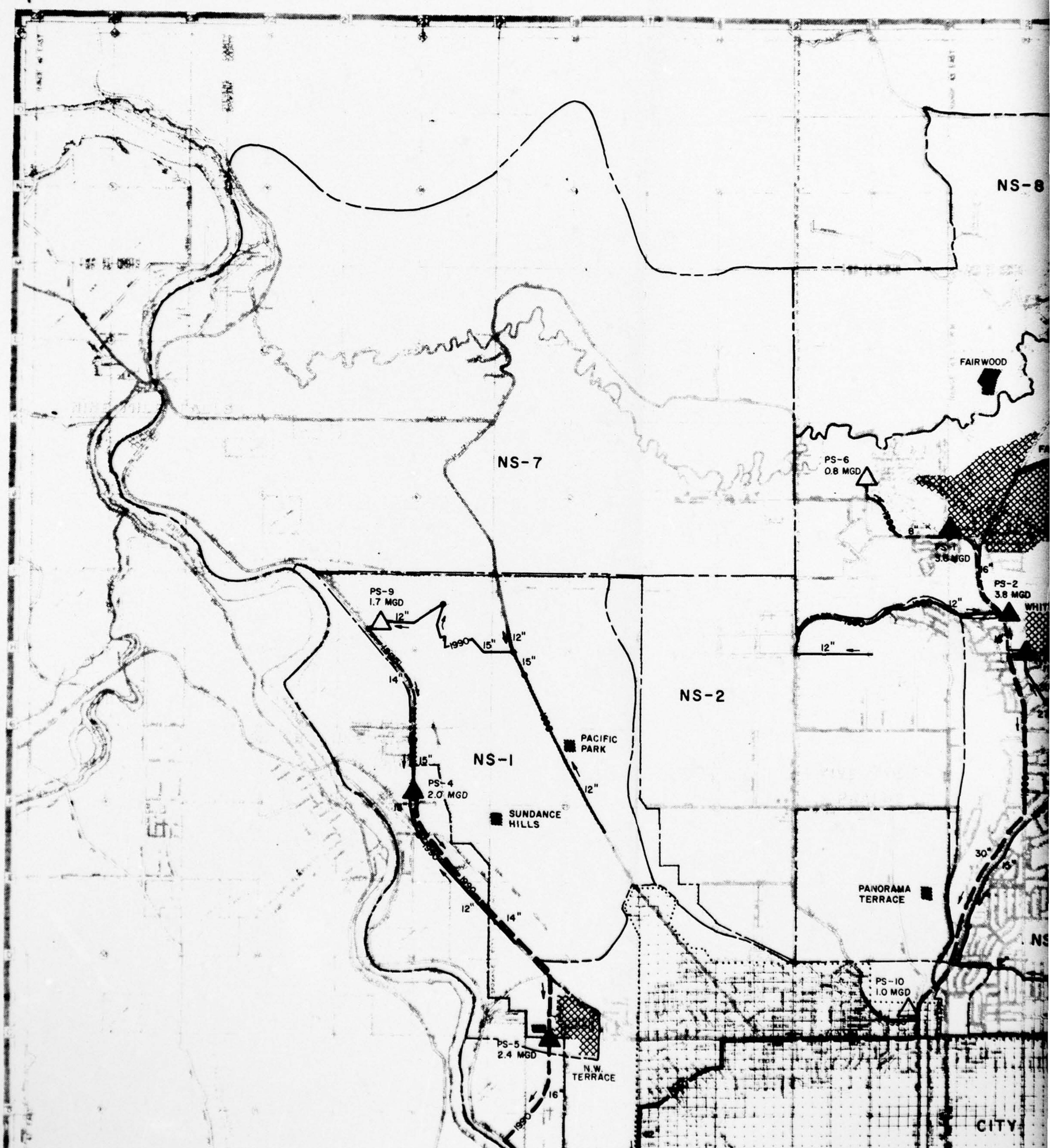
Date	
	Decision to begin implementation.
1 May 1976	Formalize basis for institutional arrangements.
1 June 1976	Make initial grant application.
1 July 1976	Award engineering contract and begin predesign engineering.
1 Jan 1977	Begin final design, acquire lands and R/W.
1 Feb 1978	Complete plans and specs. and receive grant ok's.
1 March 1978	Advertise for bids.
1 April 1978	Receive bids.
1 May 1978	Award construction contracts.
1 June 1978	Start construction of conveyance system, trunks and collection system.
1 June 1980	All conveyance from North Spokane to City STP complete and 70 percent of trunks and collection system.
1 July 1980	Divert Lidgerwood and Fairwood systems into completed trunk and conveyance system to begin delivery of raw sewage to City STP. Begin transferring individuals from septic tanks to collection system.
31 Oct 1980	Seventy percent of individuals transferred from septic tank disposal to collection system.
30 June 1981	Last individual transferred from septic tank disposal to collection system.

TABLE 10-2

IMPLEMENTATION SCHEDULE
FOR THE SPOKANE VALLEY SUBSYSTEM

Date	
1 Jan 1980	Adopt County plan and make decision to begin implementation.
1 May 1980	Formalize institutional arrangements.
1 June 1980	Make initial grant application.
1 July 1980	Award engineering contract and begin predesign engineering.
1 Jan 1981	Begin final design engineering, acquire lands and R/W.
1 Oct 1981	Complete first increment of construction plans.
1 Mar 1982	Complete last increment of construction plans.[1]
1 Apr 1982	Advertise for bids for last increment of construction.
1 May 1982	Receive bids for last increment of construction.
1 June 1982	Award contract for last increment of construction.
1 July 1982	Start construction for last increment of construction.
1 Mar 1984	All construction completed except individual house connections.
1 Apr 1984	Begin making individual house connections and begin treatment plant operation.
1 Nov 1985	Make last individual house connection.
1 Jul 1995	Possible connection of Liberty Lake to the system.

[1] Early increment of construction are advertised, awarded and under construction concurrent with continuing completion of subsequent increments of construction plans.



NS-8
FAIRWOOD
NS-7
PS-6
0.8 MGD
8"
PS-1
3.8 MGD
16"
PS-2
3.8 MGD
12"
PS-9
1.7 MGD
12"
1990
15"
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15"
14"
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NS-2
PACIFIC
PARK
NS-1
15"
PS-4
2.0 MGD
12"
SUNDANCE
HILLS
30"
16"
PANORAMA
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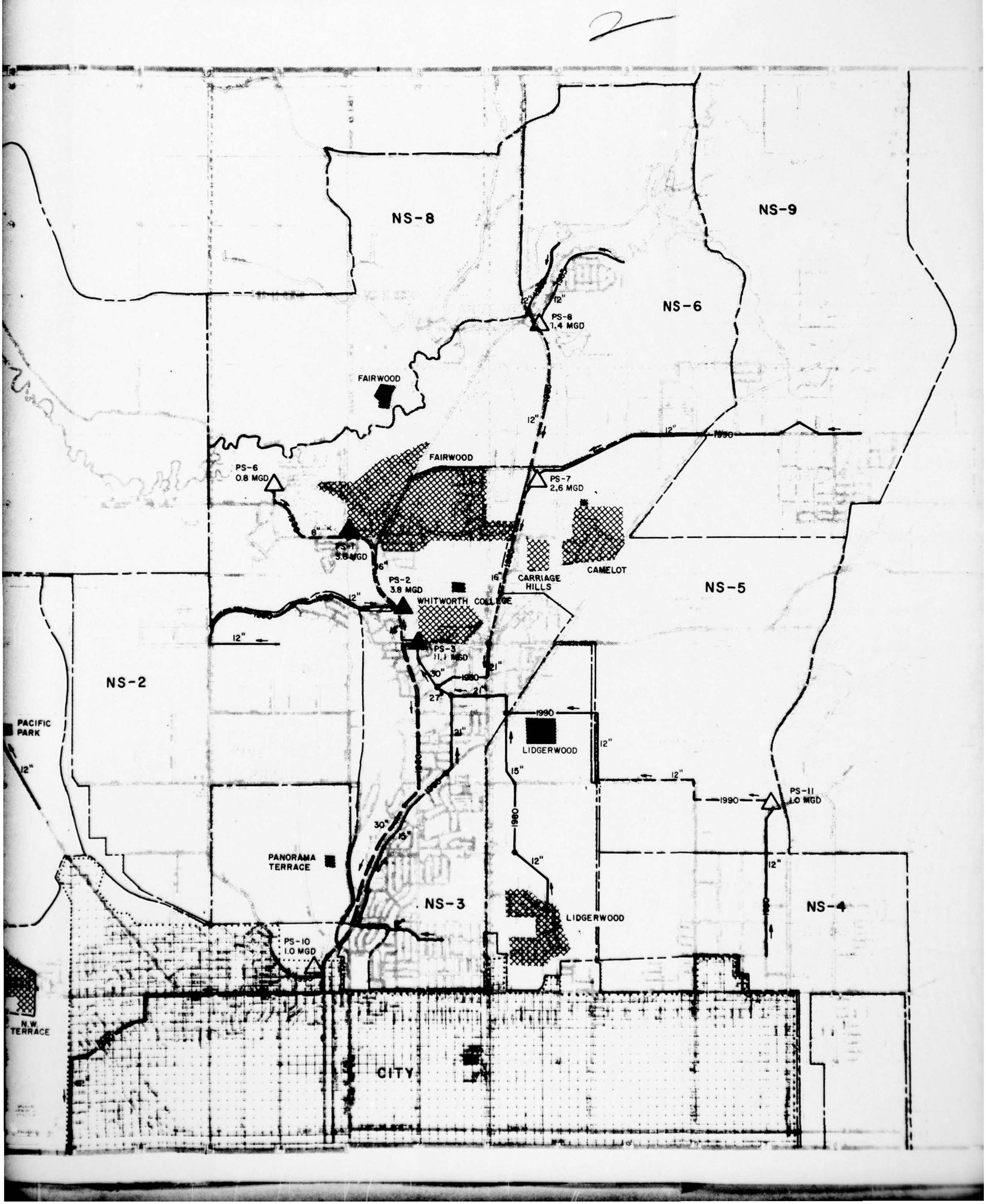
CITY



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NS-8
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PS-8
1.4 MGD
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FAIRWOOD
FAIRWOOD
1990
PS-6
0.8 MGD
PS-7
2.6 MGD
PS-1
3.6 MGD
6"
16"
PS-2
3.8 MGD
CARRIAGE HILLS
CAMELOT
NS-5
WHITWORTH COLLEGE
12"
PS-3
11.1 MGD
30"
1980
21"
27"
NS-2
PACIFIC PARK
1990
LIDGERWOOD
15"
PS-11
1.0 MGD
30"
15"
PANORAMA TERRACE
NS-3
LIDGERWOOD
NS-4
PS-10
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CITY

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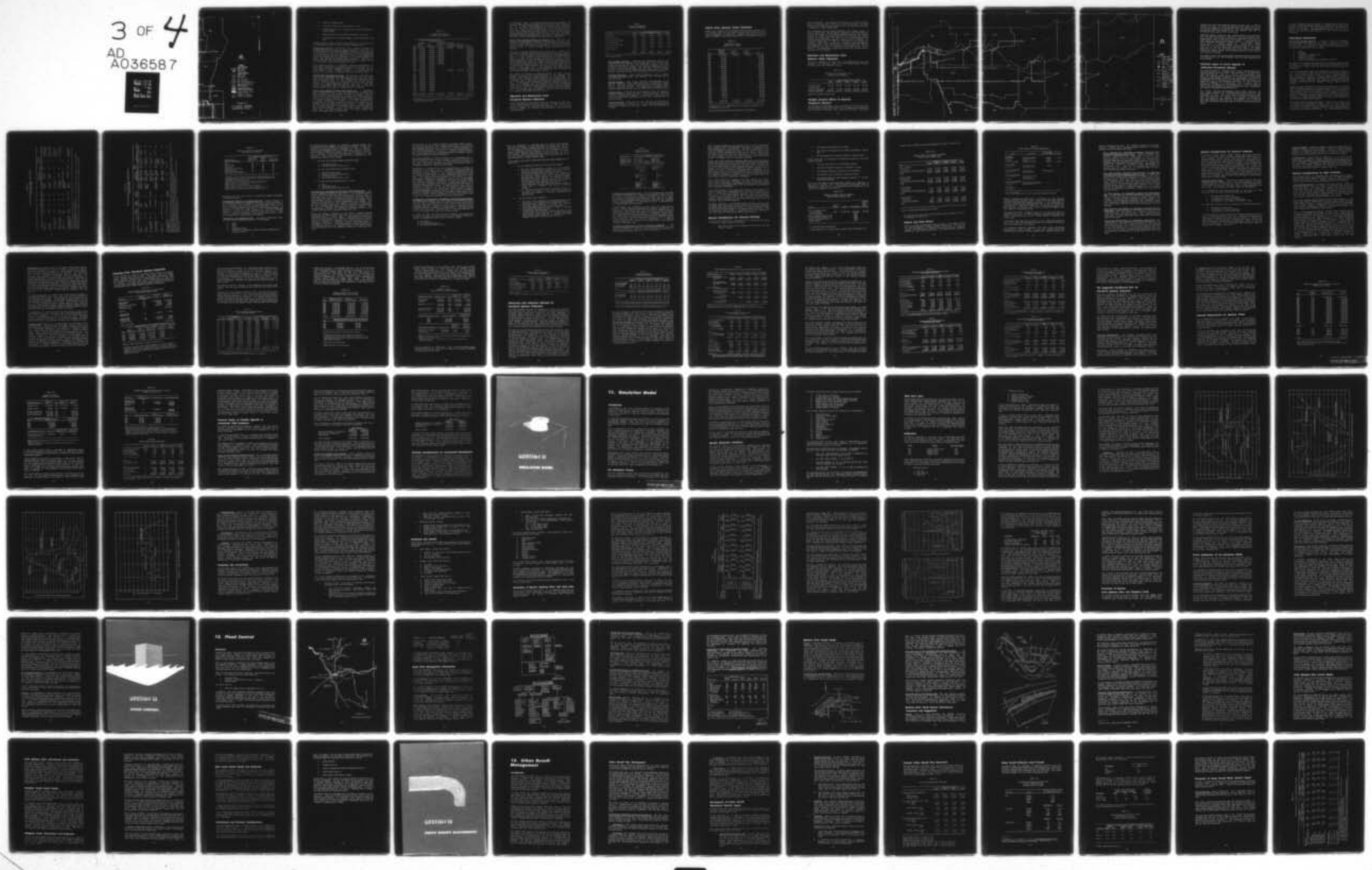


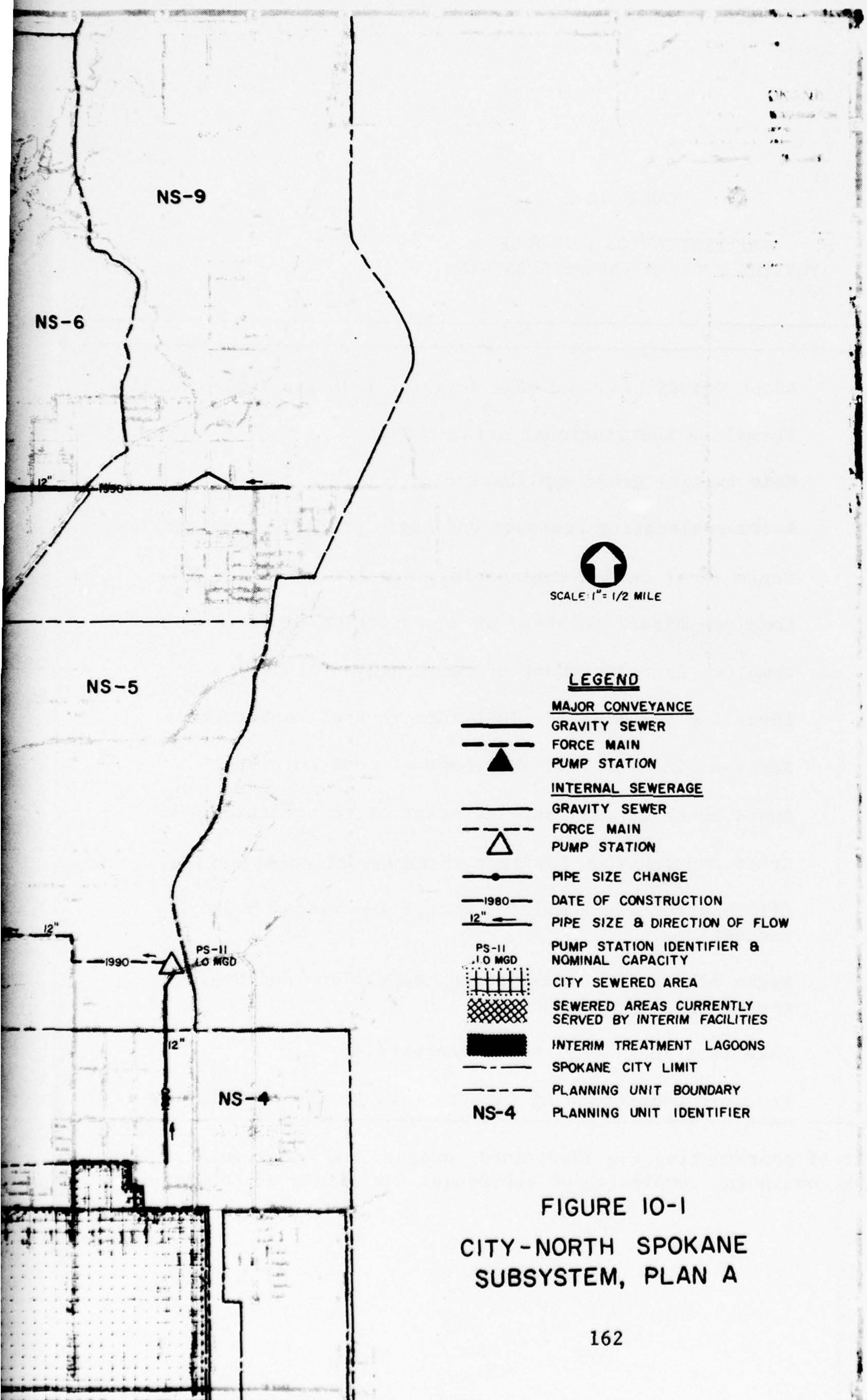


FIGURE 10-1

CITY-NORTH SPOKANE SUBSYSTEM, PLAN A

1. The City treatment plant.

2. Conveyance facilities, North Spokane to City.

3. Internal sewerage for existing and forecast development in North Spokane.

4. Internal sewerage for forecast development in the City.

5. Corrections to the existing sewage collection system in the City.

Estimated project capital costs for these elements at 1974 price level are summarized in Table 10-3 and are briefly discussed below.

Capital Costs, City STP. The City STP after committed expansion and upgrading will have an average dry weather capacity of 40 mgd and will be complete with facilities for phosphorus removal and sludge disposal. Since the forecast flow for the combined City and North Spokane areas is 40.05 mgd at the year 2000, there is no need for capital expenditure within the planning period for additions to the process elements provided. The expanded and upgraded plant represents a sunk cost of $45,000,000 which was provided 75 percent from Federal grants, 15 percent from State grants and 10 percent by the City.

It is prudent to provide for contingent additional expenditures, not specifically identified but considering possible nitrification to relieve ammonia toxicity, reaeration to raise DO of effluent and dechlorination to remove chlorine residuals. The selected contingency amounts are in two steps: $300,000 in 1980 and $700,000 in 1990.

Capital Costs, Conveyance Facilities. The conveyance facilities shown in Figure 10-1 are planned to be constructed in two stages. The first stage, to be accomplished for 1980 implementation, provides all the basic facilities to serve the North Spokane area east of Five Mile Prairie. The second stage, to be placed in service in 1990, provides facilities to convey wastewaters from the area west of Five Mile Prairie. In the period 1980 to 1990 the areas west of Five Mile Prairie continue to be served by existing interim facilities.

Capital Costs, Internal Sewerage, North Spokane Area. A preliminary plan for internal sewerage of the North Spokane area is developed and shown in Figure 10-1. The collection system is designed to be compatible with the conveyance system. The collection system is staged to gather from the most extensively built-up areas first and then extend into the area forecast to develop later. Major extensions and sewerage of existing development is carried out in 1980, 1985 and 1990. Expenditures in all other years are for sewerage of forecast new development spread uniformly by five-year periods. Internal sewerage costs include side sewers to the property line but do not include any costs on private property. Figure 10-1 shows sewers 10-inches and larger only. All other collection sewers are 8-inch minimum size except side sewers which are 6-inch size.

TABLE 10-3

CAPITAL COST[1] SUMMARY
CITY-NORTH SPOKANE SUBSYSTEM

	Internal Sewerage Facilities					
		City Service Area				
Year	N. Spokane Service Area	New Customers	Correction of Existing Sewers	Conveyance N. Spokane to City STP	Additions to City STP	Total
1980	8,647,000	152,000	7,000,000	4,297,000	300,000	20,396,000
1981	133,000	152,000	7,000,000	-	-	7,285,000
1982	133,000	152,000	7,000,000	-	-	7,285,000
1983	133,000	152,000	7,000,000	-	-	7,285,000
1984	133,000	152,000	7,000,000	-	-	7,285,000
1985	1,469,000	167,000	7,000,000	-	-	8,636,000
1986	221,000	167,000	7,000,000	-	-	7,388,000
1987	221,000	167,000	7,000,000	-	-	7,388,000
1988	221,000	167,000	-	-	-	388,000
1989	221,000	167,000	-	-	-	388,000
1990	6,328,000	205,000	-	1,408,000	700,000	8,641,000
1991	501,000	205,000	-	-	-	706,000
1992	501,000	205,000	-	-	-	706,000
1993	501,000	205,000	-	-	-	706,000
1994	501,000	205,000	-	-	-	706,000
1995	683,000	268,000	-	-	-	951,000
1996	683,000	268,000	-	-	-	951,000
1997	683,000	268,000	-	-	-	951,000
1998	683,000	268,000	-	-	-	951,000
1999	683,000	268,000	-	-	-	951,000
2000	-	-	-	-	-	-
TOTAL	23,279,000	3,960,000	56,000,000	5,705,000	1,000,000	89,944,000

[1]As Project Cost = 1.4 x Construction Cost for structural elements and 1.25 x acquisition cost for land.

A significant number of existing dwellings and other structures are served by sewage collection systems associated with interim facilities. The cost of these existing sewers is not included in the summarized costs in Table 10-3. The historical cost of these existing sewers is not known. Their cost on the same basis as new construction is estimated at $1,600,000 (including side sewers) serving the 5646 persons incorporated into the community system in 1980. The cost of the sewers serving the 1060 persons remaining to be served by interim facilities from 1980 to 1990 is estimated to be $300,000 on the same basis.

Capital Costs, Internal Sewerage, City Service Area. There are two elements of future expense relative to internal sewerage for the City. The first is construction of new sewers and side sewers to serve growth in the City area. The second is revisions to the existing combined sewerage system to correct combined sewerage overflows and local flooding.

Since the City growth population will be in the form of filling in on the routes of existing sewers plus some building in new areas, estimation of the cost of sewer additions requires that some assumptions be made as to the proportions of the various kinds of growth. Approximately 55 percent of the forecast City service area growth is in developed areas and 45 percent in lightly developed or undeveloped areas. It is estimated that half the growth in the developed area will not require sewer extensions and that half of the new side sewers will be to multiple unit structures where the average side sewer would serve 50 persons. In the other half of the developed area and in all the lightly and undeveloped areas, it is assumed that sewer extensions and side sewers are needed in proportion to growth.

The program for correction of combined overflows and local flooding proposed in the City Plan of Study submitted to DOE September 1974 extends over a period of eleven years from 1975 through 1986. The projected work consists of nine projects of average construction cost $5 million each. One project is scheduled for construction prior to 1980. For the purpose of indicating a probable schedule of demand for funds, it is assumed that one $5 million project would be completed prior to 1980 and that the eight remaining projects would be completed at the rate of one per year averaging $5 million each, 1980 through 1987. The estimated costs, converted to project costs by the addition of 40 percent, are summarized in Table 10-3.

Operation and Maintenance Costs, City-North Spokane Subsystem

Forecast operation and maintenance costs are summarized in Table 10-4. As for capital costs, all costs are expressed at 1974 price level. Costs are forecast over a 20-year planning period 1980 to 2000. The principal elements of operation and maintenance costs are briefly discussed below.

TABLE 10-4

OPERATION AND MAINTENANCE COSTS
CITY-NORTH SPOKANE SUBSYSTEM

Cost Element	Average Annual Costs at Year				
	1980	1985	1990	1995	2000
Treatment Plant	2,098,000	2,146,000	2,204,000	2,256,000	2,303,000
Conveyance Facilities	49,400	51,300	71,300	73,500	75,600
Internal Sewerage, North Spokane	32,000	34,800	39,500	62,900	77,300
Internal Sewerage, City	489,300	360,200	365,000	370,900	378,600
Customer Service, North Spokane	58,500	63,600	72,100	115,100	141,400
Customer Service, City	569,400	576,400	584,000	593,400	605,700
Interim Facilities	8,100	6,900[1]	-	-	-
TOTAL	3,304,700	3,239,200	3,335,900	3,471,800	3,581,600

[1]Operation extends to 1989.

City Treatment Facilities. Operation and maintenance costs for the committed City STP handling the combined flows of the City and North Spokane are developed for full time phosphorus removal. The costs developed in this study recognize long term major maintenance costs as an average value spread uniformly over the years. For this and other reasons of conservatism in financing studies, these costs are higher than the first year forecast costs developed by the City consultant.

Conveyance Facilities. Costs include maintenance costs on sewers, force mains and pump stations plus operating costs on pump stations including power.

Internal Sewerage. Costs include operation and maintenance for the physical collection system exclusive of costs identified as customer service. The costs are based on consideration of City budget experience and literature sources. City experience is evaluated as being probably higher than average due to problems caused by combined sewers.

Customer Service. Costs include the non-physical costs of operating a community collection system including billing, accounting, collection and general administrative expense. As for physical plant costs, the costs are derived from consideration of both City experience and literature sources.

Interim Facilities. These costs are for operation of interim facilities that are left in service for part of the planning period until displaced by connection to the central plant. The last are phased out at 1990.

Capital Costs, Spokane Valley Subsystem

Capital cost elements for the Spokane Valley subsystem consist only of the treatment plant and its outfall and the sewage collection system. Costs are summaried in Table 10-5. Treatment plant costs are for secondary treatment by activated sludge process and phosphorus removal by

TABLE 10-5

CAPITAL COST[1] SUMMARY
SPOKANE VALLEY SUBSYSTEM

Year	Internal Sewerage Facilities [2]	Treatment Plant	Disposal Outfall	Total
1985	41,587,000	9,336,000	1,708,000	52,631,000
1986	507,000	-	-	507,000
1987	507,000	-	-	507,000
1988	507,000	-	-	507,000
1989	507,000	-	-	507,000
1990	2,540,000	-	-	2,540,000
1991	462,000	-	-	462,000
1992	462,000	-	-	462,000
1993	462,000	-	-	462,000
1994	462,000	-	-	462,000
1995	2,488,000	-	-	2,488,000
1996	582,000	-	-	582,000
1997	582,000	-	-	582,000
1998	582,000	-	-	582,000
1999	582,000	-	-	582,000
2000	1,304,000	-	-	1,304,000
2001	486,000	-	-	486,000
2002	486,000	-	-	486,000
2003	486,000	-	-	486,000
2004	486,000	-	-	486,000
2005	-	-	-	-
TOTALS	56,067,000	9,336,000	1,708,000	67,111,000

[1]As Project Cost = 1.4 x Construction Cost for structural elements and 1.25 x acquisition cost for land.

[2]Does not include Liberty Lake internal sewerage or transmission.

alum precipitation. The forecast flow increase over a 20-year planning period is relatively small, being from 7 mgd to 10 mgd ADWF. The small growth does not justify stage construction so the complete 10 mgd plant is planned for initial construction.

The preliminary plan for internal sewerage of the Spokane Valley is shown in Figure 10-2. The incremental expansion of the trunk system is based on an evaluation of the present housing density and the forecast increase by years. The initial service area is based on the housing density and configuration and takes in as much contiguous area as possible without developing excessive length per unit of housing. The collection system costs at 1985 are for service to all existing development, there being essentially no existing collection elements. Trunk expansions at five-year intervals include collection of existing development at that time. Costs shown for intervening years are for sewers to serve development taking place during each five-year period, averaged over the interval.

Operation and Maintenance Costs, Spokane Valley Subsystem

Costs are summarized in Table 10-6. The significance of the cost elements is as described above for the City-North Spokane subsystem including year-round phosphorus removal.

TABLE 10-6

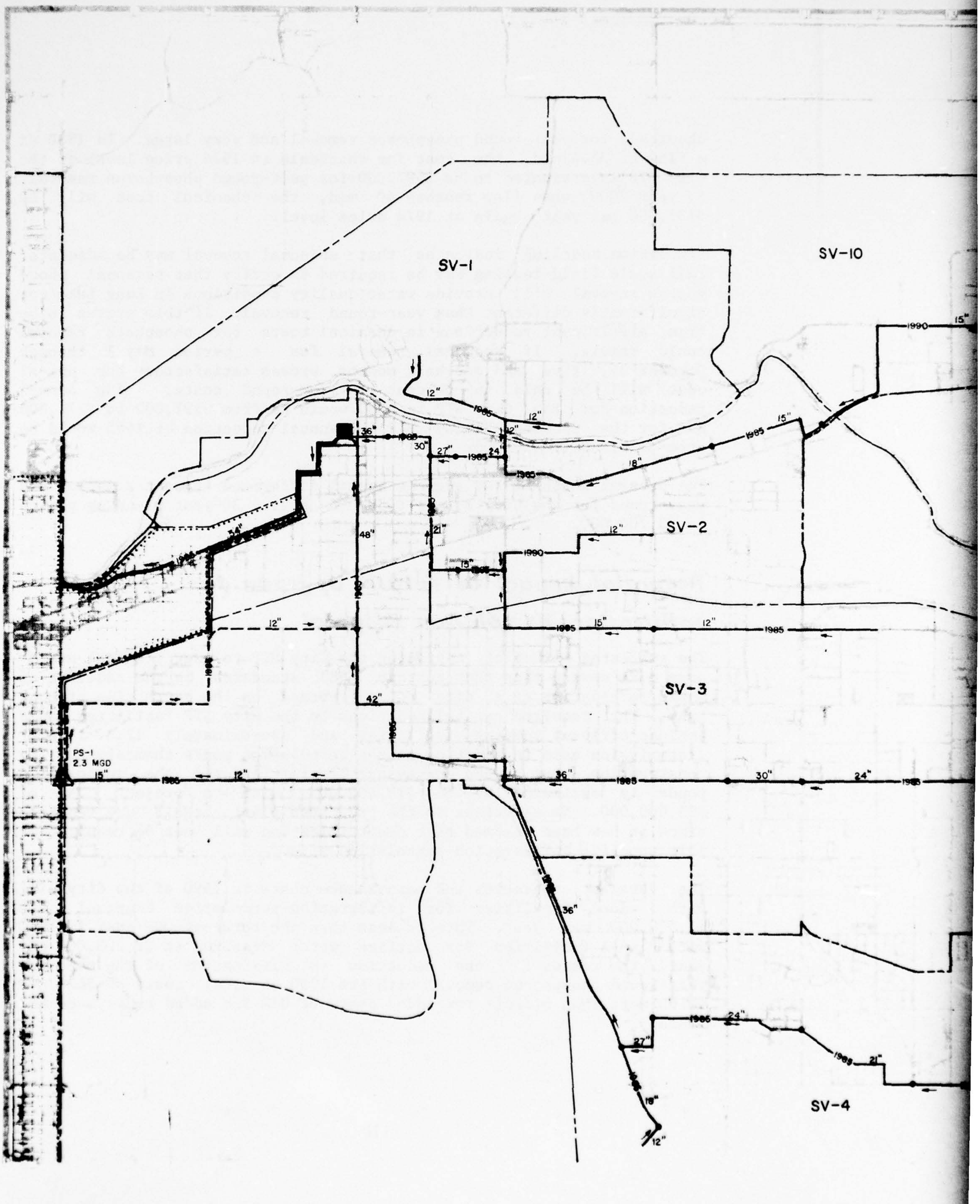
OPERATION AND MAINTENANCE COSTS
SPOKANE VALLEY SUBSYSTEM

	Average Annual Costs at Year				
	1985	1990	1995	2000	2005
Treatment Plant and Outfall	667,000	692,000	713,000	742,000	762,000
Internal Sewerage 1/	84,000	93,000	105,000	118,000	128,000
Customer Service 1/	153,000	169,000	192,000	216,000	234,000

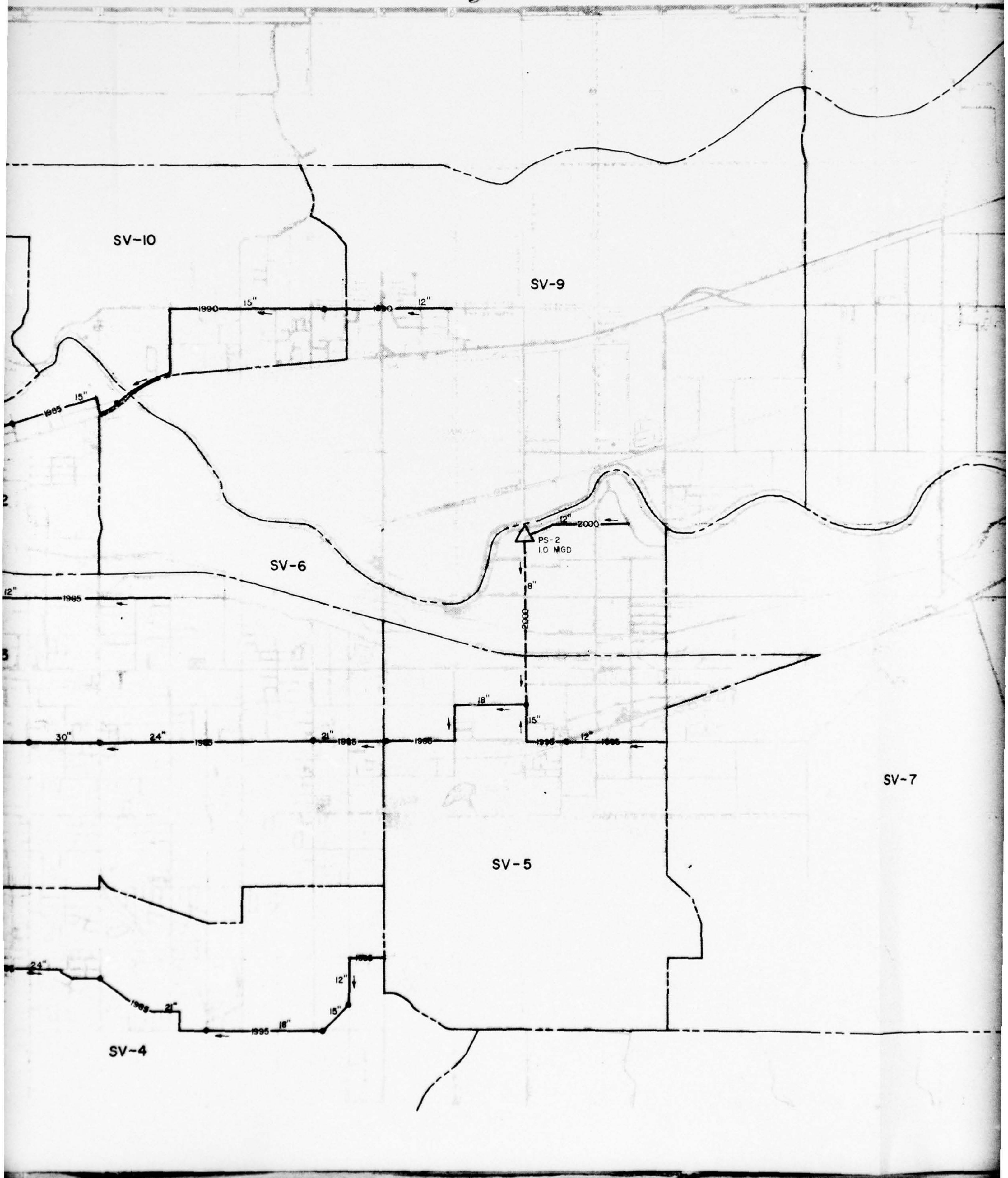
1/Does not include Liberty Lake.

Possible Financial Effects of Seasonal Phosphorus Removal

The operation and maintenance costs for both the City STP in Table 10-4 and the Spokane Valley STP in Table 10-6 are based on year-round phosphorus removal in accordance with current DOE direction. The cost of


SV-1
SV-10
SV-2
SV-3
SV-4
PS-1
2.3 MGD
12"
15"
18"
21"
24"
27"
30"
36"
42"
48"
1985
1990

2


SV-10
SV-9
SV-6
SV-5
SV-7
SV-4
PS-2
1.0 MGD
1990
15"
12"
1985
2000
8"
18"
30"
24"
21"
1995

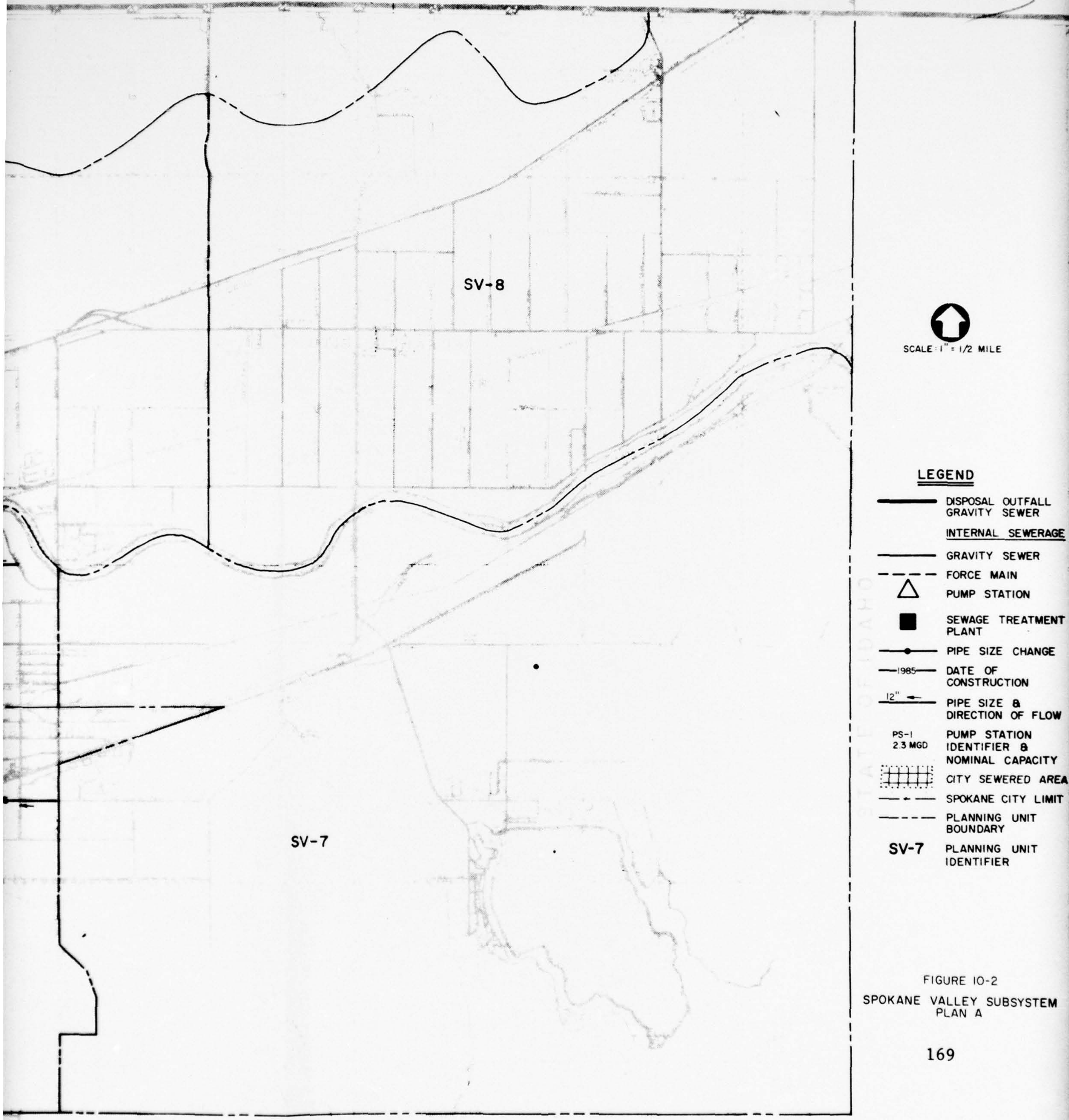


FIGURE 10-2
SPOKANE VALLEY SUBSYSTEM
PLAN A

chemicals for year-round phosphorus removal are very large. In 1980 at a flow of 32.4 mgd, the cost for chemicals at 1974 price level at the City STP is estimated to be $597,000 for year-round phosphorus removal. By year 2000, when flow reaches 40 mgd, the chemical cost will be $737,000 per year, again at 1974 price level.

Simulation modeling indicates that seasonal removal may be adequate. Full scale field testing may be required to verify that seasonal phosphorus removal will provide water quality conditions in Long Lake not significantly different than year-round removal. If this proves to be true, significant reductions in chemical costs for phosphate removal could result. If seasonal removal for a period May 1 through October 15, five and one-half months, proves satisfactory the annual cost will be only 46 percent of year-round costs. The annual reduction for the City STP in 1980 would be from $597,000 to $274,000 and for the Spokane Valley STP the annual reduction at 1985 would be from $129,000 to $59,000.

The present worth of the average annual difference between seasonal and year-round for the City STP of $350,000 over a 20-year planning period is $3,700,000.

Potential Impact of Future Upgrade to Infiltration-Percolation Disposal

The suggested method of upgrading the City STP to meet disposal standards more severe than the current 1983 standards is the addition of rapid percolation at a site on a terrace on the north side of Long Lake. The required capital additions to the City STP facilities would include effluent pumping facilities and approximately 12.6 miles of transmission main in addition to the percolation ponds themselves. The construction cost of the conveyance facilities and the percolation ponds is estimated to be $18,400,000 with a project cost of $25,600,000. No additions to the treatment plant itself are required since it has been assumed that denitrification will not be required at this specific infiltration-percolation site.

The forecast operation and maintenance costs in 1990 of the City STP with added facilities for infiltration-percolation disposal are $1,900,000 per year. This is less than the forecast O&M cost in 1990 with Plan A facilities for surface water disposal at $2,200,000 per year. The reason for the reduction is elimination of the need for year-round phosphorus removal with its 1990 chemical costs of $670,000 which more than offsets the added costs of O&M for added conveyance and ponds.

A similar calculation made for upgrade of a Spokane Valley plant by the addition of rapid percolation ponds is proportionately much more severe than for the City STP. Total estimated project cost for the required addition is $15,700,000. Advanced physical-chemical costs are of a similar order and may be more attractive in the future with improved technology.

Institutional Alternatives

The Field of Candidate Agencies. A canvas of State of Washington statues indicates that there are six agency types that have varying sewerage powers. The functional and financing characteristics of these six agency types are summarized in Tables 10-7 and 10-8 respectively. The six basic agency types are as follows:

1. County
2. City/Town
3. Metropolitan Municipal Corp.
4. Sewer/Water District
5. Irrigation District
6. Diking and Drainage/Sewer Improvement District

In addition to individual agencies acting to perform a sewerage function there is provision for inter-local agency cooperation to perform these functions. Tables 10-8 and 10-9 provide detailed agency descriptions.

Two of the above agency types may be eliminated from further consideration. An irrigation district may be formed in unincorporated territory only, and its voting structure, which is based on land ownership, is not a satisfactory vehicle to represent public opinion. Diking and drainage and sewer improvement districts also have a landowner voting structure. The above districts are generally intended for local improvement projects and are not intended to manage a regional sewerage program.

Another existing institution that requires consideration is the Spokane Regional Planning Conference, a vehicle created by the City and County under provisions of RCW 35.63.070 and 36.70.060. It is recognized by the Governor's office as the clearing house for planning in the metropolitan Spokane area and is certified by HUD as meeting the qualifications for a regional planning agency. In the area of transportation planning, it is recognized by the Urban Mass Transit Administration and by the Federal Highway Administration.

The Spokane Regional Planning Conference, however, has no legal basis for becoming an implementation agency. The City and County have inter-local cooperation powers for implementation. These powers would not result in or require a separate entity but would operate within the existing City and County institutions. The Spokane Regional Planning

TABLE 10-7

STATE OF WASHINGTON SEWERAGE AGENCY CHARACTERISTICS
FUNCTIONAL POWERS

Agency	Planning	Collection	Treatment	Disposal	Other Services	Provisions for Cooperation with Other Agencies	Power of Ordinance	May Provide Local Assessment Financing	Miscellaneous
County RCW 36.94	Regional	Yes	Yes	Yes	All county functions	36.94.040 and ICA[1]	Yes	Yes	Cities have primary authority to operate facilities within city
City/Town RCW 35.67	Citywide	Yes	Yes	Yes	All municipal functions	35.67.300 and ICA	Yes	Yes	Facility construction usually requires vote 35.92.070
Metropolitan Municipal Corp. -RCW 35.58	Regional	Yes	Yes	Yes	Water, solid waste, transit[2]	ICA	Yes	Yes	May require local compliance with regional plans
Sewer/Water District[3] RCW 56.16/57.08.065	Local system	Yes	Yes	Yes	Water district: street lighting	56.08.060	Yes	Yes	Can't include city without city consent
Irrigation District RCW 87.	Local system	Yes	Yes	Yes	Irrigation, power, domestic, water, drainage	None specified	No	Yes	--
Diking and Drainage Dist. / Sewer Improvement Dist. RCW 85.03&85.16	Local collection	Yes	Limited	Limited	Diking and drainage	None specified	Limited	Yes	Local assessment financing form

[1]Interlocal Cooperation Act, RCW 39.34.
[2]See RCW 35.58.050 for other regional function. Constituent agencies may continue to provide non-regional municipal services.
[3]Water districts providing sewerage services may exercise powers of a sewer district, RCW 57.08.065.

TABLE 10-8

STATE OF WASHINGTON SEWERAGE AGENCY CHARACTERISTICS
FINANCING POWERS

Agency	Power to Tax	Power to Levy Rates & Charges	Uniform Charges Required	Lien for Delinquent Charges	Other	General Indebtedness Bonds: Election[1]	General Indebtedness Bonds: Limitations	General Indebt. - Revenue Bonds	Revenue Bonds: Election	Revenue Bonds: Limitations	Refunding Bonds
County RCW 36.67	Yes	Yes	For each class	Yes	Charges must meet costs[2]	Required over 1.5 % A.V.	8% interest maximum	None spec.	None required by statute[1]	No interest max-30 yr	Yes
City/Town RCW 35.67	Yes	Yes	For each class	Yes	Special tax allowed 35.21.280	Always required	No interest max-30 yr max	Yes	Required over 1.5% A.V.[3]	30 yr max	Yes
Metropolitan Municipal Corp. -RCW 35.58	Yes	Yes	No restrictions	No provision	--	Required over 1.5 % A.V.	No interest max-40 yr max	Yes	None required by statute	None	Yes
Sewer/Water District[4] RCW 56.16/57.08.065	Yes	Yes	For each class	Yes	Charges must meet costs[2]	Always required	No interest max-30 yr max	None spec.	Always required (1/2 majority) to 1.5% A.V.[5]	30 yr max	Yes
Irrigation District RCW 87.	No	Assessments	Per benefit	Yes	---	Always required	8% interest maximum	N.A.[6]	Required if over 10 yr term	No	Yes
Dikingand Drainage Dist./ Sewer Improvement Dist. RCW 85.08&85.16	No	Assessments	Per benefit	Yes-unpaid assessments	--	N.A.	N.A.	N.A.	N.A.	N.A.	Yes

[1]Washington Constitution, Article 7, Section 2 seems to always require a 3/5 majority vote over 1.5% A.V.
[2]Where revenue bonds issued, but costs of general indebtedness can be tax supported.
[3]An election is also required under 1.5% A.V. unless a health hazard exists.
[4]Water district providing sewerage services may exercise powers of a sewer district, RCW 57.08.065.
[5]Except in case of additions and betterments.
[6]Not applicable.

TABLE 10-9

MATRIX OF INSTITUTIONAL ARRANGEMENTS
AND STATUTORY LIMITATIONS

Institutional Agency or Combination	Areas to be Administered: City Plans North Spokane Alone	Spokane Valley Alone	Entire Urban Planning Area
Metro[5]	X[1]	X[1]	O
County, Alone	X[2]	O[3]	X[2]
City, Alone	X[4]	X[4]	X[4]
Sewerage District, Alone	X[2]	O[3]	X[2]
City-County Co-op	O	O	O
Sewer District-City Co-op	X[6]	X[6]	X[6]
City-County-Local Agency Co-op	O	O	O

X indicates that the agency or combination is unsatisfactory for the administrative area for the reason cited in numbered reference notes.
O indicates feasible alternatives.
[1]Not possible since the area served contains only one city.
[2]Cannot operate in incorporated areas without contract.
[3]Could cover all except Millwood.
[4]Cannot operate outside the City without contract.
[5]Metro, by law, is not alone. It is in cooperation with all.
[6]Sewer District cannot use Inter-Local Cooperation Act.

Conference does not have a place as a potential wastewater management implementation agency.

Considerations Specific to the Engineering Plan. Certain features of the engineering wastewater management plans have an important impact on both formulation and evaluation of alternative institutional plans. The most important feature of the suggested engineering plan for its impact on institutional alternatives is that two separate systems are suggested to serve the urban planning area. The second important feature is that one of the two systems serves an area with a large degree of sewerage development while the other system serves an area with essentially no present sewerage development.

Formulations to the Engineering Plan. The field of alternative agencies after initial screening consists of the Following:

1. Metro
2. County
3. City
4. Sewerage District
5. Inter-local cooperation contracts between combinations of the above (Co-op)

The engineering plan suggests two physically separate systems: the alternatives of either separate institutional arrangement for each subsystem or a single institutional arrangement for both. A matrix of institutional arrangements for the two subsystems separately and combined is shown in Table 10-9 together with an indication of the statutory limitation of each agency or combination of agencies for the assignment. These limitations reduce the field of candidates to the agencies listed below in each system.

1. To serve the City-North Spokane subsystem alone:

   a. City-County Co-op
   b. City-County-Sewer District Co-op

2. To serve the Spokane Valley subsystem alone:

   a. County-Millwood Co-op
   b. Sewerage District-Millwood Co-op
   c. City-County Co-op
   d. City-County-Sewer District Co-op

3. To serve the urban planning area as a unit:

   a. Metro
   b. City-County Co-op
   c. City-County-Sewer District Co-op

Consideration of One Agency for the Entire Urban Planning Area. Because the suggested engineering plan results in two separate sewerage systems, and because these two systems are at much different levels of development and may have different implementation schedules, there is little functional need for one agency to administer and operate both of these systems, at least at the initial phases of the program. Being separated, the systems can operate independently of one another. Similarly, each system will be more capable of developing a system's budget than a regional organization. Physical separation also diminishes the need to standardize materials and construction methods. Less standardization provides the flexibility sometimes required to solve technical problems which individual projects may face.

Despite the physical separation of the systems, a regional sewerage organization can handle several functions more effectively than the individual agencies. A single agency is advantageous in dealing with Federal and State agencies to present a coordinated effort in seeking approval of planning and financing. And, a single agency would have a continuing advantage in maintaining contact with higher levels of government in the future. A regional agency has further advantage as a clearinghouse, keeping local agencies abreast of each other's activities and funneling State and Federal information to individual agencies.

The main issue to be decided is whether, at present, there is sufficient need or advantage to have a single regional agency for the entire urban planning area rather than consider the optimum arrangement for each subsystem separately. One of the most important considerations is the time and costs required to establish a regional sewerage organization. This potentially critical disadvantage must be weighted against the benefits derived from the organization.

The primary advantage of a Metro is that it is an advantageous tool to provide cooperative action where a number of cities are involved. In this case where there are only two cities involved, one of which is very small, interagency cooperation can provide the necessary degree of coordination without the formation difficulties.

Designation of a Section 208 area-wide planning agency, as provided for under Public Law 92-500, was not considered a viable institutional alternative for the Spokane area. The practice regarding Section 208 designation is being revised by EPA. Originally designation was made on a "need" basis as required to solve "substantial water quality problems." This criterion has been modified to some extent in recent designations. Before such a designation could be made in the Spokane area, special arrangements or agreements would have to be made between local agencies including modification of agency authorities. These necessary agency agreements and authority modifications would result in substantial implementation delays. Present actions for the control of wastewater as directed by the DOE are expected to result in water quality improvements in the Spokane River in the vicinity of Spokane. Wastewater management planning as required under Public Law 92-500 is expected to preclude the development of substantial water quality problems in the future. However, designation of a Section 208 agency could be made in the future in accordance with needs and practice.

<u>Consideration of Cooperative Arrangements between Existing Entities.</u> The Spokane urban planning area has a number of governmental entities with some level of sewerage powers including two cities, ten irrigation districts, four water districts, one sewer district and several county improvement districts. Except for the City none of these entities are presently capable of providing the proposed level of sewerage service to more than a local area. Large portions of the urban planning area are not yet served by any agency with sewerage powers.

As shown in Table 10-9 and the above discussions, the required capability for serving both subsystem areas can be developed through cooperative arrangements between existing agencies, either:

- City-County
- City-Sewerage District
- City-County-Sewerage District

There are advantages to involving both the County and Sewerage Districts, the former to provide coordination in dealing with the City and the latter to operate collection systems and provide local control. It is not necessary to involve the City in the arrangements for the Spokane Valley subsystem since neither City areas nor City facilities are involved. With the County involved in both, the County is in a position to provide an area planning input that would yield some of the same advantages as a single regional agency.

A plan based on the above is described below and shown schematically in Table 10-10.

1. For the subsystem serving the City and North Spokane:

    a. The City would continue to operate its own sewerage facilities, including the treatment plant, the collection system and customer services inside city limits.
    b. In areas outside the City, the County, after adoption of the sewerage general plan, would serve as the master sewerage agency, would construct and operate conveyance facilities, and would contract with the City for treatment services and for joint operation and construction of certain mutually used conveyance facilities.
    c. Local improvement districts (sewerage) would be formed in county areas to construct and maintain collection systems.
    d. In the event that an area provided sewerage service by the County is annexed to the City, then the sewerage functions would transfer to the City in accordance with RCW 36.94.180.

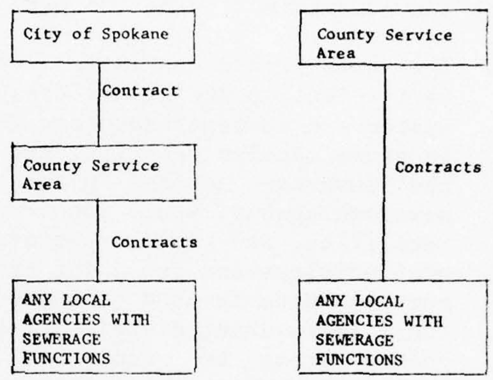
2. For the Spokane Valley subsystem:

    a. The County, after adoption of the sewerage general plan, would serve as the sewerage program management agency.
    b. The County would construct and operate the treatment facilities, disposal facilities and trunk sewers.
    c. Local improvement districts would be formed to construct and maintain collection systems.
    d. In areas where local agencies provide some level of sewerage service, such as the Town of Millwood, the County would obtain written approval to manage the regional sewerage program as required by RCW 36.94.040.

TABLE 10-10

INSTITUTIONAL CONFIGURATION
FOR URBAN PLANNING AREA

Sewerage Functions	Service Area: City of Spokane - No. Spokane	Service Area: Spokane Valley
Lead Planning Agency	City of Spokane	Spokane County
Treatment & Disposal	City of Spokane	Spokane County
Interceptor System O&M	City of Spokane, Spokane Co.	Spokane County
Collection System O&M	City, County, Local Agencies	County, Local Agencies
Customer Contact	City, County, Local Agencies	County, Local Agencies



Selection of an Institutional Plan. The plan described above and shown in Table 10-10 is based on a cooperative arrangement between the City and County for the City-North Spokane subsystem and for a County arrangement in the Spokane Valley subsystem. This plan has the advantages of easier implementation and political acceptance that recommend it over a regional agency. The remaining factors to be considered are the financing powers and resources.

Financing powers and resources are very broad for three types of agency: cities, counties and metropolitan municipal cooperations. The selection of any of these agency types for a role in regional sewerage administration insures that the regional sewerage agency has the necessary broad financing powers and resources. In addition, common financing powers may be coordinated through inter-local cooperative agreements. Therefore, the institutional plan shown in Table 10-10 and described above also meet the financing requirements of a regional sewerage program and is suggested for implementation of the suggested wastewater management plan.

Institutional Requirements for Other Structural Alternatives. The foregoing suggestion is specifically applicable to Plan A, the suggested structural plan. Other structural plans that are considered in final evaluation include Plans B, C, D, E, F, G and H.

Plan D is the suggested plan for upgrade of Plan A to meet interpreted 1985 standards. Plan D is compatible with Plan A and requires no different institutional considerations. City-County cooperation for the City-North Spokane subsystem and County for the Spokane Valley subsystem are equally appropriate for Plan D as for Plan A. Plans E and F are similar in their institutional requirements to Plans A and D since they also combine the City and North Spokane in one subsystem and include the Spokane Valley in a separate subsystem.

Plans B and H which provide for separate subsystems for the City, North Spokane and Spokane Valley have the simplest institutional requirements in that each subsystem can utilize the existing agency in which they are located except that, for North Spokane subsystem, City-County cooperation is still required if the entire North Spokane service area is handled as a unit. If either of these plans were considered, it is likely that the City areas of North Spokane would be separated from the North Spokane service area functionally by pumping these areas to the City system, thus making it possible to have City and County areas separated with no need for cooperative arrangements.

Plan G which provides for combining the North Spokane and Spokane Valley service areas into a subsystem, with the City separate, is similar in its institutional requirements to Plans B and H as described above, with the same possibility of the City elements of North Spokane being functionally separated.

Plan C which combines all service areas together in one treatment and disposal system could be implemented by a City-County cooperation or a Metro. A City-County cooperation is suggested over a Metro for reason cited above. In this case, however, the very reason for consideration of Plan C could be an expression of local opinion that both a single regional system operated by a single regional agency are worth the additional cost and effort required.

The unique condition of the Spokane Metropolitan Region with the City and County being practically the only existing entities with wastewater management needs and capabilities points to their involvment in practically any plan either singly or in cooperation with each other. Even the potential of incorporation of West Plains areas in an urban wastewater plan would not alter this condition significantly.

General Consideration for Financial Planning

There are four concerns to a financial plan for developing the funding to implement a public improvement program:

1. The revenue program which eventually must meet all costs not offset by grants.

2. The amount and availability of grants.

3. The method of meeting project funding requirements through debt.

4. The development of an equitable method of sharing costs.

Factors which must be considered in formulating responses to the above concerns include:

1. The cost and timing of the improvement program.

2. The kind of agencies selected to implement the plan.

3. The existing financial obligations of the agencies.

4. The forecast rate of growth of the service areas.

5. The existing physical plant presently operated by the participating agencies.

The costs and timing of the improvement program are summarized in Tables 10-3 through 10-6. The selected institutional plan is summarized in Table 10-10. The existing financial obligations of the agencies are summarized in Table 10-11.

TABLE 10-11

SUMMARY OF BONDED DEBT FOR SEWERAGE
SPOKANE URBAN PLANNING AREA

Entity	Year of Issue	Amount	Outstanding	Average Annual Bond Service
City of Spokane Sewer Revenue Bonds	1960	$1,000,000	$348,000	$72,000
Town of Millwood			NSBO[1]	
Vera Irrigation District #15			NSBO	
Whitworth Water District #1			NSBO	
Liberty Lake Sewer Dist. #1			NSBO[2]	
Spokane County			NSBO	

[1] No Sewerage Bonds Outstanding.

[2] Voters approved $1.7 million sewer revenue bonds in November 1974.

Forecast rate of growth of service populations is shown in Table 10-12.

TABLE 10-12

FORECAST NUMBER OF SEWERAGE CUSTOMERS[1]
SPOKANE URBAN PLANNING AREA

	Number of Customers at Year				
Area	1980	1985	1990	1995	2000
City of Spokane					
Residential	58,035	58,505	59,010	59,560	60,130
Commercial & Non-Residential	8,705	8,775	8,850	8,935	9,020
Total	66,740	67,280	67,860	68,495	69,150
Spokane Valley					
Residential	17,410	19,245	21,055	23,050	24,685
Commercial & Non-Residential	2,610	2,885	3,160	3,460	3,705
Total	20,020	22,130	24,215	26,510	28,390
North Spokane					
Residential	5,740	6,605	9,815	12,025	14,875
Commercial & Non-Residential	860	990	1,470	1,805	2,230
Total	6,600	7,595	11,285	13,830	17,105
North Spokane					
Inside City	955	1,186	2,679	3,302	4,004
Outside City (County)	5,645	6,409	8,606	10,528	13,101
Total	6,600	7,595	11,285	13,830	17,105

[1]Based on Equivalent Dwelling Units (EDU's).

The inventory and historical cost of physical plant sewerage facilities is summarized in Table 10-13.

Federal and State Grants

Public Law 92-500, administered by EPA, provides a 3-step grant program for total development of "sewage treatment" facilities. The law has extended the definition of treatment facilities to include collection systems and storm drainage facilities. The administrative guidelines,

TABLE 10-13

SUMMARY, HISTORICAL COST OF EXISTING SEWERAGE FACILITIES

Entity	Description	Estimated Major Facilities Investment[1]	Total Grants
City of Spokane			
Treatment Plant	40 mgd primary treatment	$ 628,000	$ 171,000
Interceptors	24 inches to 72 inches	1,030,000	--
Pump Stations	numerous	127,000	--
Improvements in Progress	secondary treatment plant	45,800,000	41,101,000
Town of Millwood			
Treatment Facility	small treatment system	10,000[2]	--
Interceptors	collection system only	--	--
Vera Irrigation District #15			
Treatment Facility	three small systems	Donated by Developer	--
Interceptors	collection system only	--	--
Whitworth Water District #2			
Treatment Facility	operates developer-owned treatment system	--	--
Interceptors	collection system only	--	--
Liberty Lake Sewer District #1			
Treatment Facility	possible purchase of private system	--	--
Interceptors	collection system only	--	--
Spokane County			
Treatment Facility		--	--
Interceptors		--	--

[1]Based on entity records.
[2]Estimated treatment system cost out of $59,000 total investment including collection sewers.

however, discourage the eligibility of collection or storm drainage facilities except in unusual cases. Public Law 92-500 grant funds are available for facilities planning under Step I, for preparation of contract drawings and specifications under Step II and for construction under Step III. Grants are available to 75 percent of project cost. The allocation of priorites and control of grant disbursement is by DOE, subject to concurrence by EPA.

Washington State offers companion grants of up to 15 percent which are administered by DOE to the same eligibility requirements as Public Law 92-500. A state grant may not be offered without a commitment of a Federal grant.

While Federal and State grant assistance is not assured throughout the project life, this study assumes that grants will continue to be available at the same level as at present.

As a financing safeguard, assistance from other State and Federal programs has not been included in this plan. Application for such funds should be made and pursued expeditiously wherever practical to

assist in reducing local costs. The following summarizes the primary sources of Federal grant and loan funding available for sewerage programs, other than Public Law 92-500.

E.D.A. Programs, U.S. Department of Commerce (The Public Works and Economic Development Act of 1965). Certain designated economically depressed areas may obtain grants for public works projects. Grants are of up to 80 percent of costs. In recent years applicability of E.D.A. grant programs for construction of sewerage works has been limited to those projects which could demonstrate a strong impact on economic growth. The program has further been limited in the amount of funds appropriated and distributed. E.D.A. funds are not normally made available to projects which are eligible for a significant amount of E.P.A. grant funding under Public Law 92-500.

Basic Water and Sewer Facilities Grant Program, U.S. Department of Housing and Urban Development (The H.U.D. Act). Grants for construction of public works facilities in communities and metropolitan areas are available in amounts of up to 50 percent of land and construction costs. H.U.D. has not recently received significant appropriations to fund the water and sewer facilities program and it is unlikely that funds from this source would be available unless there is a future policy revision. H.U.D. funds would not be applicable to facilities eligible for E.P.A. funding and would be applicable to collection systems only, exclusive of lateral sewers.

The "701" Program, U.S. Department of Housing and Urban Development. Provides funds for solving comprehensive planning problems. Grants of up to 66.7 percent of the cost of comprehensive planning programs, including wastewater management planning elements, are available. This program has functionally been superseded in the area of wastewater management planning by the provisions of Public Law 92-500, section 303e and 201 for basin planning and facilities planning.

Public Facility Loan Program, U.S. Department of Housing and Urban Development. Loans provide up to 100 percent of project costs for sewage facilities. This program is a companion program to the H.U.D. basic water and sewer facilities grant program applicable essentially to unusual conditions where conventional loan funding cannot be obtained.

Farmers Home Administration, U.S. Department of Agriculture. Provides grants to rural areas of less than 4000 population for comprehensive plans for sewer system development up to 50 percent of cost of sewer systems. This program also provides for loan funds to assist in that portion of rural projects ineligible for F.H.A. or E.P.A. grant funding. Legislation and appropriations decisions may influence the availability of funding through the above programs.

General Considerations for Revenue Programs

An entity's sewerage system revenue program must meet three basic tests. First, total annual revenues should exceed operating and bond service expenses. Second, revenue from industrial users should be obtained on the basis of their proportional use of the system's facilities in accordance with EPA Guidelines published in the Federal Register, 28 February 1973. The third test relates to the principle that the sewerage system revenue program should generate funds to place the system on a self-supporting and self-renewing basis, i.e., annual revenues, after meeting operating expenses, should equal or exceed annual depreciation of capital plant based on original cost and estimated useful life of the system. To meet this test, the combination of: (1) annual capital outlay, (2) bond principal payments and (3) contributions to a wastewater capital reserve fund must equal or exceed annual depreciation of capital plant.

Sewer User Service Charge. The sewer user service charge is the basic continuing revenue producer other than ad valorem taxes. The sewer service charge can be allocated in a variety of ways providing alternative methods of equitably spreading costs to those benefiting from the service. The ad valorem tax does not have this flexibility.

For a residential sewer service charge some of the bases for cost allocation that have been considered include the following:

1. Flat rate per dwelling unit
2. In proportion to water consumption
3. In proportion to the size of water meter
4. In proportion to the number of bedrooms or baths

For commercial customers, the rate structure may include bases such as:

1. Equivalent dwelling units
2. In proportion to water consumption
3. In proportion to water meter size

It is not within the scope of this study to devise detailed rate structures. The objective of this study is to determine the total share of financing to be produced from sewer service charges as compared with other sources. For the purpose of evaluating the impact on each customer, the estimated service charge is expressed in terms of the flat rate per dwelling unit. This is compatible with the present method of levying service charges in the City.

Connection Charges. Connection charges are lump sum payments made by a customer at the time his service begins. This type of charge does not provide a continuing source of revenue. A connection charge is usually regarded as a payment by the new customer to purchase his share in the existing facilities previously paid for by the existing customers.

Ad Valorem Taxes. Taxes levied in proportion to the value of the property are a potential revenue source that can be used to pay for either bond amortization or recurring operation and maintenance costs. Due to the trend of commitment of taxes for other civic purposes up to the limit of the maximum statutory rate and because of the inequities inherent in the payments related to the services, this revenue source has not been favored recently for sewerage financing.

General Considerations for Debt Financing

The principal classes of long-term debt instruments used to finance projects which have community-wide benefit are: (1) general obligation bonds and (2) revenue bonds. Special assessment bonds are used to finance facilities which provide immediate and localized benefits.

General Obligation Bonds are secured by the full faith and credit of the issuing agency, and the issuer is obligated to levy ad valorem (property) taxes to pay annual bond interest and principal, to the extent other funds are not available. Although this power and obligation to levy ad valorem taxes forms the underlying security for such bonds, no taxes need be levied if other revenues are sufficient to meet bond service. The issuer may use revenues from service charges or other sources to meet the required payments on the bonds.

Because the bonds are secured directly by the taxing authority of the agency, they usually command about 0.5 percent lower interest rate than revenue bonds. Because of their security features, their tax exempt status and their general acceptance by the bond market, general obligation bonds lend themselves readily to competitive public sale at the lowest interest cost available to the borrower.

With a revenue-supported general obligation bond, revenues from the enterprise are pledged toward payment of debt service. This limits the potential increase in the general tax rate. Self-supporting general obligation bonds have the advantages of a revenue bond, but maintain the low interest rate and ready marketability of general obligation bonds secured by the taxing power of the issuing agency. Under the present statutes, general obligation bonds of a constitutionally created entity (cities, counties) must receive an affirmative vote of three-fifths (60 percent) of those casting a vote on the measure to authorize the bonds. General obligation bond limits are set at 5 percent of the total assessed valuation of taxable property for counties. In the case of cities and towns providing for sewer service, an additional indebtedness of up to 5 percent of assessed valuation is allowed. This, therefore, allows a city or town up to a total of 10 percent indebtedness upon a three-fifths majority vote for sewer service.

Revenue bonds are secured solely by a pledge of the revenues from the facility or enterprise they are used to acquire, construct or improve. This type of bond may be issued to finance sewerage system improvements. Usually a simply majority vote is required. In the case of both the City and County, revenue bonds may be issued with only governing board approval for sewerage facilities conforming to an approved general plan. The agency cannot levy taxes for the payment of revenue bond service and there is no obligation to levy taxes for the maintenance and operation of the enterprise which produces the revenues pledged to pay revenue bond services. There is no legal limitation on the amount of authorized revenue bonds which may be issued, but from a practical standpoint the size of the issue must be limited to an amount which will require annual interest and principal payments which are well within the facilities' revenues that are available for bond service.

The principal advantage of revenue bonds is that funds for payment of the bonds are derived solely from those who use the facilities for which the bonds were issued. Revenue bonds can never become a lien or charge against real property. An additional advantage lies in the fact that approval by three-fifths of the voters is not required, as in the case of general obligation bonds. Revenue bonds are not considered applicable debt toward an entity's general obligation bonding capacity which preserves an entity's general obligation bonding capacity to meet its needs to finance non-revenue-producing facilities.

A disadvantage of this type of bond is that revenues to secure their payment must be from 25 to 50 percent above actual requirements to insure their saleability. In the case of grant-aided facilities, however, this requirement may fulfill the need to obtain sufficient funds for depreciation accruals or for capital improvements, uses which also satisfy the 25 to 50 percent coverage factor to market the bonds.

Assessment bond financing is a possible vehicle for a project of identifiable benefit. A utility local improvement district (ULID) can be established and assessments spread for projects of special local benefit. Assessments constitute a lien against the benefited property which serves as security for issuance of bonds to finance the project costs. These liens would not represent an encumbrance on any overlapping district and do not affect any district's debt capacity. The property securing the lien must, however, be of sufficient value to more than cover the assessment. Assessments must be spread only over property that benefits from the project. Because unbuildable property receives no benefit, an engineering determination of buildable lots must be made in spreading assessments. Assessment bonds have specific application to finance collection sewers, lateral sewers and trunk sewers where the benefits of the facilities can be easily identified.

Financing Costs, City-North Spokane Subsystem

To test if there is a need for additional capital reserves, the calculation shown on Table 10-14 is made. This shows that the average annual guideline depreciation for the subsystem facilities is under $2.0 million per year with a total 20-year depreciation of less than $35 million. The table shows that in every year depreciation is greately exceed by contemplated capital expense additions to the system and therefore, that further capital accruals are unnecessary.

TABLE 10-14

ESTIMATED DEPRECIATION COMPARED TO CAPITAL EXPENSE
CITY AND NORTH SPOKANE SUBAREA

Facilities	Life for Expenditure Test[1] (Years)	Original Cost	Annual Depreciation
Starting 1980			
40 mgd STP	30	$45,800,000	$1,527,000
Pump Stations (Existing)	30	508,000	17,000
Additions to STP	30	474,000	16,000
New Pump Stations	30	2,625,000	88,000
Subtotal			$1,648,000
Starting 1985			
Pump Stations	30	$ 804,000	$ 27,000
Starting 1990			
Pump Stations	30	$ 1,734,000	$ 58,000
Treatment Plant	30	2,282,000	76,000
Total - Year 2000			$1,809,000

Depreciation and Capital Expense Comparison

Year	Annual Depreciation	Less: Bond Principal	Less: Total Capital Expenditures	Less: Installment Principal	Additional Capital Accrual[2]
1980	$1,648,000	$ 155,000	$11,118,000	$213,000	--
1985	1,675,000	345,000	1,489,000	213,000	--
1990	1,809,000	657,000	12,815,000	213,000	--
1995	1,809,000	930,000	4,342,000	213,000	--
2000	1,809,000	1,310,000	5,934,000	213,000	--

[1]Based on federal guidelines for capital recovery test.

[2]One measure of annual capital expense adequacy is to fund the higher of either annual depreciation or capital expenditures plus debt principal payments. Because capital expenditures plus debt principal exceeds annual depreciation, no accrual to capital reserve appears necessary during the period of this study.

Forecast capital and operation and maintenance costs are presented in Tables 10-3 and 10-4 in terms of costs at 1974 price levels. To put these cost forecasts in terms required for financial planning it is necessary to first estimate the amount that will be offset by grants and then give recognition to inflationary trends and express the costs in terms of the estimated price at the time when they occur. It is also necessary to recognize the need for depreciation reserves or capital improvements to maintain the system and to include the cost of debt service.

Debt service costs are estimated on the assumption that revenue bonds would be used and that the interest rate would be 6.75 percent for 25 years.

That part of the sewerage facilities that will have purely local benefit must be paid for by the local areas receiving the benefit. Sewage collection systems in sizes below 12-inch and associated pump stations are included in this category. The capital costs for local benefit facilities at escalated price levels are shown in Table 10-15. For the City area the existing sewer corrections for bypass elimination are included in the local benefit category although they involve sewers

TABLE 10-15

CAPITAL COST SUMMARY FOR LOCAL BENEFIT FACILITIES
FOR CITY AND SPOKANE SUBSYSTEM

		North Spokane		City			
Year	Escalation Index[1]	Internal Sewerage Facilities Cost[2]	Escalated Cost	New Customer Facilities Cost[2]	Escalated Cost	Existing Sewers Corrections	Escalated Cost
1980	1.58	$ 6,885,000	$10,878,000	$ 152,000	$ 240,000	$ 7,000,000	$ 11,060,000
1981	1.70	133,000	226,000	152,000	258,000	7,000,000	11,900,000
1982	1.83	133,000	243,000	152,000	278,000	7,000,000	12,810,000
1983	1.96	133,000	261,000	152,000	298,000	7,000,000	13,720,000
1984	2.11	133,000	281,000	152,000	321,000	7,000,000	14,770,000
1985	2.27	480,000	1,090,000	167,000	379,000	7,000,000	15,890,000
1986	2.44	221,000	539,000	167,000	407,000	7,000,000	17,080,000
1987	2.62	221,000	579,000	167,000	438,000	7,000,000	18,340,000
1988	2.82	221,000	623,000	167,000	471,000	--	--
1989	3.03	221,000	670,000	205,000	506,000	--	--
1990	3.26	3,726,000	12,147,000	205,000	668,000	--	--
1991	3.50	501,000	1,754,000	205,000	718,000	--	--
1992	3.76	501,000	1,884,000	205,000	771,000	--	--
1993	4.04	501,000	2,024,000	205,000	828,000	--	--
1994	4.35	501,000	2,179,000	268,000	892,000	--	--
1995	4.67	683,000	3,190,000	268,000	1,252,000	--	--
1996	5.02	683,000	3,429,000	268,000	1,345,000	--	--
1997	5.40	683,000	3,688,000	268,000	1,447,000	--	--
1998	5.81	683,000	3,968,000	268,000	1,557,000	--	--
1999	6.24	683,000	4,262,000	268,000	1,672,000	--	--
2000	6.71	--	--	--	--	--	--
Total		$17,425,000	$53,915,000	$3,504,000	$14,746,000	$56,000,000	$115,570,000

[1] As a financing safeguard, costs are escalated to year shown.
[2] Does not include trunk sewers 12" and larger in diameter, force mains and pump stations.

larger than 12 inches. It is assumed that the cost of the City sewer correction program will be offset by grants to the extent of 90 percent. Although eligible under the terms of PL 92-500, there is no commitment for this, particularly for the storm sewer portion, and little precedent, so it is a highly questionable issue. The costs are, however, so enormous that the City probably would not undertake the proposed program unless it is largely grant funded. The escalated costs for the City correction program offset by 90 percent grants is shown in Table 10-16 along with the computation of bond service costs on the net funding requirement.

TABLE 10-16

FINANCING SEPARATION AND CORRECTION OF EXISTING SEWERS--CITY OF SPOKANE

Year	Escalated Cost of Sewer Corrections	State and Federal Grants[1]	Net Local Share
1980	$ 11,060,000	$ 9,954,000	$ 1,106,000
1981	11,900,000	10,710,000	1,190,000
1982	12,810,000	11,529,000	1,281,000
1983	13,720,000	12,348,000	1,372,000
1984	14,770,000	13,293,000	1,477,000
1985	15,890,000	14,301,000	1,589,000
1986	17,080,000	15,372,000	1,708,000
1987	18,340,000	16,506,000	1,834,000
Totals	$115,570,000	$104,013,000	$11,557,000

Year	Bond Sales to Finance Separation and Correction: Principal Amount[3]	Bond Sales to Finance Separation and Correction: Average Annual Bond Service[4]
1980	$2,300,000	$193,000
1982	2,650,000	222,000
1984	3,070,000	258,000
1986	3,540,000	297,000

[1]Assumes sewer corrections are fully grant eligible.

[2]If equalization method is used, may finance some sewer corrections from equalization compensation payments. If other cost sharing methods are used, finance through combination of bonds and pay-as-you-go.

[3]Offer bonds on alternate years.

[4]Based on 25 years at 6.75% interest.

Capital cost financing on an escalated price level with estimated grants offset is shown in Table 10-17 for all elements in the City-North Spokane subsystem. It is assumed that all interregional conveyance and treatment facilities are eligible for 90 percent grants, but that system-wide trunks 12 inches and larger are not eligible for any grant funding. Note that Table 10-17 summarizes local benefit items other than City connections separately and at 1974 price level in terms which are the basis for computation of a connection charge.

TABLE 10-17

SUMMARY OF FINANCING
FOR CITY AND NORTH SPOKANE SUBSYSTEM

Regional Facilities	Escalated Costs	Year	State & Fed. Grants	New Local Cost
North Spokane	$6,789,000	1980	$6,110,000	$ 679,000
Conveyance	4,590,000	1990	4,131,000	459,000
Additions to City STP	$ 474,000	1980	$ 426,000	$ 48,000
	2,282,000	1990	2,054,000	228,000
12 inches & Larger	$2,784,000	1980	--	$2,784,000
Trunks, FM and PS	2,244,000	1985	--	2,244,000
	8,481,000	1990	--	8,481,000

Bond Sales Necessary by Year	Bond Sale Amount[1]	Average Annual Bond Service[2]
1980	$ 3,870,000	$325,000
1985	2,470,000	207,000
1990	10,085,000	846,000

Local Benefit Facilities	Cost in 1974	Customers Benefiting (EDU's)	Cost Per Customer Benefited[3]
Internal North Spokane	$17,425,000	17,105	$1,020
Internal City	3,504,000	2,410	1,460

[1]Based on net local cost plus about 10% reserve funds and issuance costs.
[2]Based on 25 years at 6.75%.
[3]Based on 1974 dollars. Escalate at inflation rate and collect as a connection charge.

Forecast operation and maintenance costs for the City-North Spokane subsystem escalated to future price levels, by five year increments, are summarized in Table 10-18.

TABLE 10-18

ESCALATED OPERATION AND MAINTENANCE COSTS
CITY - NORTH SPOKANE SUBSYSTEM[1]

Cost Element	Year				
	1980	1985	1990	1995	2000
Treatment Plant	$3,084,000	$4,228,000	$5,819,000	$7,964,000	$10,870,000
Conveyance Facilities	73,000	101,000	188,000	259,000	357,000
Internal Sewerage-North Spokane	47,000	69,000	104,000	222,000	365,000
Internal Sewerage-City	719,000	710,000	964,000	1,309,000	1,787,000
Customer Service-North Spokane	86,000	125,000	190,000	406,000	667,000
Customer Service-City	837,000	1,136,000	1,542,000	2,095,000	2,859,000
Interim Facilities-City[2]	12,000	14,000	--	--	--

[1]Based on Table 10-4.
[2]Interim facilities to be charged at cost to those users receiving the service.

Alternative Cost Allocation Methods for City-North Spokane Subsystem

The basic financing cost data are summarized in Tables 10-17 and 10-18. These tables do not address the problem of how these costs are to be allocated among those served. There are two basic approaches to allocation where facilities are shared by service elements belonging to different agencies. One is to allocate costs in proportion to amounts of capacity used or reserved to each party. This has been the traditional approach. The other method is a plan in which all parties pay equal amounts for equal services. These two methods are referred to herein as the "capacity share" and "equalization" methods respectively. Note that the costs under discussion here are the system costs exclusive of those which have been designated local benefit elements.

The bases for capacity sharing are developed in Table 10-19 which shows two allocations, one for the treatment and disposal facilities which are shared by the entire subsystem and the other for the conveyance facilities which are shared only by those customers in the North Spokane service area. The basis for share allocations is in proportion to forecast average dry weather flow. A differentiation is made between the basis for sharing capital costs versus operation and maintenance costs. Capital costs are to be shared on the basis of the proportion of flow at year 2000, in effect providing for payment in proportion to that part of the design capacity reserve for each party. Operation and maintenance costs are shared on the basis of the ratio of flow at the time that the operation and maintenance costs occur. For example, the County area of North Spokane would be allocated 11.1 percent of capital costs for treatment based on reservation of 4.44 mgd of capacity at year 2000, but in 1980 would be allocated 6.3 percent of operation and maintenance costs based on actual flow in that year of 2.05 mgd.

TABLE 10-19

CAPACITY AND COST SHARES
CITY AND NORTH SPOKANE SUBSYSTEM

	Treatment and Disposal Share Allocation[1] at Year									
	1980		1985		1990		1995		2000	
	Flow	%	Flow	%	Flow	%	Flow	%	Flow	%
City and North Spokane										
North Spokane-County	2.05	6.3	2.38	7.0	2.97	8.2	3.65	9.6	4.44	11.1
North Spokane-City	0.35	1.1	0.42	1.2	0.93	2.5	1.15	3.0	1.36	3.4
City Service Area	30.00	92.6	31.40	91.8	32.40	89.3	33.40	87.4	34.20	85.5
Totals	32.40	100.0	34.20	100.0	36.30	100.0	38.20	100.0	40.00	100.0

	Conveyance Facilities Share Allocation[2]									
	Flow	%	Flow	%	Flow	%	Flow	%	Flow	%
North Spokane Only										
North Spokane-County	2.05	85.4	2.38	85.0	2.97	76.2	3.65	76.0	4.44	76.5
North Spokane-City	0.35	14.6	0.42	15.0	0.93	23.8	1.15	24.0	1.36	23.5
Totals	2.40	100.0	2.80	100.0	3.90	100.0	4.80	100.0	5.80	100.0

[1] Operating cost shares for treatment and disposal based on above percentage of flows in each year. Capital cost shares for treatment and disposal facilities based on year 2000 percentage of flows.

[2] Operating costs for conveyance facilities to City STP based on percentage of flows in each year. Capital cost for conveyance facilities to City STP based on year 2000 percentage of flow.

The cost allocations developed in Table 10-19 are applied to the costs developed in Tables 10-17 and 10-18 to arrive at cost allocations on the capacity share basis in Table 10-20. Note that the payment by the County areas for capital costs of treatment are regared as a purchase of a share of capacity and therefore, include debt cost repayment to the City at the same rate as assumed for bonded debt herein. City expenses and revenues are developed in Table 10-21 to balance against the cost sharing developed in Table 10-20. Note that at this point the City local benefit costs are added in to complete the budgetary picture. Local benefit costs represent 39 percent of total expenses at 1980. Results for 1980 are a monthly service charge of $5.80 and a total connection charge for treatment of $315 per dwelling unit. In addition, each new dwelling unit would have to pay its share of additions to internal sewerage, averaging $2,305, which may be covered by developer donated facilities or by LID financing. Note that the internal sewerage cost or connection charge for same is not included in either the total revenue or total expense in Table 10-21. Note that the $44,000 paid by County areas for capital treatment cost appears as a revenue item to the City.

TABLE 10-20

CAPACITY ALLOCATION OF OPERATING AND CAPITAL COST--CITY AND NORTH SPOKANE SUBSYSTEM

Expenses---Facility	Year 1980	1985	1990	1995	2000
Operating--Treatment Plant					
North Spokane (Co.) Share	$ 194,000	$ 296,000	$ 477,000	$ 765,000	$ 1,207,000
City Share	2,890,000	3,932,000	5,342,000	7,199,000	9,663,000
Total	$3,084,000	$4,228,000	$5,819,000	$7,964,000	$10,870,000
--Conveyance Facilities					
North Spokane (Co.) Share	$ 62,000	$ 86,000	$ 143,000	$ 197,000	$ 273,000
City Share	11,000	15,000	45,000	62,000	84,000
Total	$ 73,000	$ 101,000	$ 188,000	$ 259,000	$ 357,000
Capital----Existing STP					
NS (Co.) Purchase Capacity[1]	$ 44,000	$ 44,000	$ 44,000	$ 44,000	$ 44,000
----Bond Issues[2]--1980 Issue					
NS (Co.) Share = 75.6%	$ 246,000	$ 246,000	$ 246,000	$ 246,000	$ 246,000
City Share = 34.4%	79,000	$ 79,000	$ 79,000	$ 79,000	$ 79,000
--1985 Issue					
NS (Co.) Share = 74.9%	$ --	$ 158,000	$ 158,000	$ 158,000	$ 158,000
City Share = 23.5%	--	$ 49,000	$ 49,000	$ 49,000	$ 49,000
--1990 Issue					
NS (Co.) Share = 74.9%	$ --	$ --	$ 634,000	$ 634,000	$ 634,000
City Share = 35.1%	--	--	212,000	212,000	212,000

[1]Based on 11.1% of local share of $4,699,000. Repayment amortized for 25 years at 6.75%.
[2]Based on county share of 11.1% for STP, 76.5% for conveyance, trunks, force mains and pump stations.

TABLE 10-21

CITY REVENUES AND EXPENSES CAPACITY COST SHARING
CITY AND NORTH SPOKANE SUBSYSTEM

	Year 1980	1985	1990	1995	2000
Number of Connections (EDU's)	67,695,	68,466	70,539	71,797	73,154
New EDU's (Annual)	155	415	250	270	230
Monthly Service Charge	$5.80	$7.75	$10,65	$13.60	$17.50
Connection Charge [1]					
Internal Sewerage Share	$2,305	$3,315	$4,760	$6,820	$9,800
Treatment Facilities Share	$315	$405	$650	$935	$1,340
Service Charge - De-Escalated	$3.95	$3.93	$4.03	$3.85	$3.71
Revenues					
Service Charges	$4,712,000	$6,367,000	$9,015,000	$11,717,000	$15,362,000
Connection Charges (Treatment)	49,000	187,000	163,000	252,000	308,000
STP Capacity Payments from N.S.	44,000	44,000	44,000	44,000	44,000
Total Revenues	$4,805,000	$6,598,000	$9,222,000	$12,013,000	$15,714,000
Expenses					
Treatment O & M	$2,890,000	$3,932,000	$5,342,000	$ 7,199,000	$ 9,663,000
Conveyance O & M	11,000	15,000	45,000	62,000	84,000
Internal Sewerage O & M	719,000	710,000	964,000	1,309,000	1,787,000
Customer Service	837,000	1,136,000	1,542,000	2,095,000	2,859,000
Present Bond Service	72,000	--	--	--	--
1980 Bond Issue (Share)	79,000	79,000	. 79,000	79,000	79,000
1985 Bond Issue (Share)	--	49,000	49,000	49,000	49,000
1990 Bond Issue (Share)	--	--	212,000	212,000	212,000
Bonds for Sewer Corrections	193,000	673,000	970,000	970,000	970,000
Total Expenses	$4,801,000	$6,594,000	$9,203,000	$11,975,000	$15,705,000

[1]Internal sewerage portion paid as one-time charge at time of connection, or donated by developer and added to price of new home, or paid through LID assessment financing. Revenue is not shown on table.

The revenues and expenses of the County areas in North Spokane are developed in Table 10-22 similarly to the development of the City revenues and expenses described above. The results are a $9.50 monthly service charge to County area dwelling units. The regional treatment connection charge is the same as the City at $315 per dwelling unit. The same comments apply here with respect to the internal sewerage "connection charge."

Turning now to the equalization method, revenues and expenses are developed in Table 10-23 for the entire combined service area of the City and North Spokane, including both City and County subunits. The costs shown in Table 10-23 are for treatment and conveyance only and do not include any local benefit costs. The regional operation and maintenance costs are the sum of treatment and conveyance costs from Table 10-18. The bond service costs are from Table 10-17 and include costs associated with treatment, conveyance and trunk sewers 12 inches and larger. The time identified as equalization compensation is based on the amount required to reimburse the net City investment in regional facilities of $5,313,000 over a period of 20 years with interest on the balance. The principal installments are $213,000 per year and the first year (1980) interest on the unamortized balance is $265,000 for a first year total of $478,000.

The principle of the equalization method being equal charges for equal service, there is only one service charge applicable throughout the combined service area. This is computed at $4.40 per dwelling unit. Note that this value should not be compared with the values shown in Tables 10-21 and 10-22 because it represents only the cost of regional facilities whereas the values in Tables 10-21 and 10-22 also contain local benefit costs. The regional treatment connection charge at $315 per dwelling unit is the same as for the capacity share method.

Table 10-24 develops revenue and expenses for the City areas by combining the regional facility costs developed in Table 10-23 with local benefit costs. Under subarea expenses, the City has the cost of operating and maintaining all regional facilities and offsetting against this the entire equalization compensation is a revenue item. The result is a City service charge in 1980 of $6.06 per month including regional and local benefit costs. This compares with $5.80 per month for the capacity share method.

In a similar manner, Table 10-25 develops revenue and expenses for the County portion of the North Spokane service area under equalization assumptions. The result is a County area total service charge of $6.37 per month. This compares with $9.50 per month by the capacity share method.

Both of the foregoing methods of cost allocation have been utilized elsewhere and are regarded as equitable. In this particular case there are obvious advantages to the County areas to the equalization method

TABLE 10-22

NORTH SPOKANE (COUNTY) REVENUES AND EXPENSES CAPACITY COST SHARING CITY AND NORTH SPOKANE SUBSYSTEM

	Year				
	1980	1985	1990	1995	2000
Number of Connections	5,645	6,409	8,606	10,528	13,101
New EDU's (Annual)	120	360	325	430	370
Monthly Service Charge	$9.50	$11.25	$17.30	$18.00	$19.75
Connection Charge					
Internal Sewerage Share[1]	$1,610	$2,315	$3,325	$4,765	$6,845
Treatment Facilities Share	$ 315	$ 450	$ 650	$ 935	$1,340
Service Charge De-Escalated	$6.46	$5.71	$6.55	$5.10	$4.18
Revenues					
Service Charges	$644,000	$ 865,000	$1,787,000	$2,274,000	$3,105,000
Connection Charges (Treatment)	38,000	162,000	211,000	402,000	496,000
Total Revenues	$682,000	$1,027,000	$1,998,000	$2,676,000	$3,601,000
Expenses					
Treatment O & M	$194,000	$ 296,000	$ 477,000	$ 765,000	$1,207,000
Conveyance O & M	62,000	86,000	143,000	197,000	273,000
Internal Sewerage O & M	47,000	69,000	104,000	222,000	365,000
Customer Service	86,000	125,000	190,000	406,000	667,000
STP Capacity Purchase	44,000	44,000	44,000	44,000	44,000
1980 Bond Issue (Share)	246,000	246,000	246,000	246,000	246,000
1985 Bond Issue	--	158,000	158,000	158,000	158,000
1990 Bond Issue	--	--	634,000	634.000	634,000
Total Expenses	$679,000	$1,024,000	$1,996,000	$2,672,000	$3,594,000

[1]Paid as a one time charge at time of connection, or donated by developer and added to the price of a new home, or paid through LID assessment financing. Revenue is not shown on the table.

TABLE 10-23

SUBAREA REVENUES AND EXPENSES EQUALIZED COSTS CITY AND NORTH SPOKANE SUBSYSTEM

	Year				
	1980	1985	1990	1995	2000
Number of Connections (EDU's)	73,340	74,875	79,145	82,325	86,255
New EDU's (Annual)	275	775	575	700	500
Service Charge (Monthly)	$4.40	$5.50	$7.75	$9.35	$11.60
Connection Charge (Regional)	$ 315	$ 450	$ 650	$ 935	$1,340
Service Charge De-Escalated	$2.99	$2.80	$2.94	$2.65	$2.46
Revenues					
Service Charge	$3,873,000	$4,942,000	$7,360,000	$9,237;000	$12,007,000
Connection Charges	87,000	349,000	374,000	655,000	804,000
Total Revenues	$3,960,000	$5,291,000	$7,734,000	$9,892,000	$12,811,000
Expenses					
Regional Operation and Maintenance	$3,157,000	$4,329,000	$6,067,000	$8,223,000	$11,227,000
Equalization Compensation	478,000	425,000	372,000	319,000	266,000
Bond Service	325,000	532,000	1,315,000	1,315,000	1,315,000
Total Expenses	$3,960,000	$5,286,000	$7,694,000	$9,857,000	$12,808,000

TABLE 10-24

CITY REVENUES AND EXPENSES EQUALIZED COSTS
CITY AND NORTH SPOKANE SUBAREA

	Year				
	1980	1985	1990	1995	2000
Number of Connections (EDU's)	67,695	68,466	70,539	71,797	73,154
New EDU's Annual	155	415	250	270	230
Service Charge (Monthly)					
Subareawide	$4.40	$5.50	$7.75	$9.35	$11.60
Local	1.66	2.55	3.67	4.71	6.10
Connection Charge (Internal)[1]	$2,305	$3,315	$4,760	$6,820	$9,800
Service Charge-De-Escalated	$4.12	$4.09	$4.33	$3.98	$3.75
Revenues					
Subareawide Service Charges	$3,574,000	$4,519,000	$ 6,560,000	$ 8,056,000	$10,183,000
Local Sewerage Service Charges	1,348,000	2,095,000	3,107,000	4,058,000	5,355,000
Equalization Compensation	478,000	425,000	372,000	319,000	266,000
Total Revenues	$5,400,000	$7,039,000	$10,039,000	$12,433,000	$15,804,000
Expenses					
Subarea Expenses	$3,574,000	$4,519,000	$ 6,560,000	$ 8,056,000	$10,183,000
Internal Sewerage O & M	719,000	710,000	964,000	1,309,000	1,787,000
Customer Service	837,000	1,136,000	1,542,000	2,095,000	2,859,000
Present Bond Service	72,000	--	--	--	--
Bonds For Sewer Corrections	193,000	673,000	970,000	970,000	970,000
Total Expenses	$5,395,000	$7,038,000	$10,036,000	$12,430,000	$15,799,000

[1]Represents the level of charge to finance local benefit improvements. The revenue from this charge is not shown on this table.

TABLE 10-25

NORTH SPOKANE (COUNTY) REVENUES AND EXPENSES EQUALIZED COSTS
CITY AND NORTH SPOKANE SUBSYSTEM

	Year				
	1980	1985	1990	1995	2000
Number of Connections (EDU's)	5,645	6,409	8,606	10,528	13,101
New EDU's Annual	120	360	325	430	370
Service Charge (Monthly)					
Subareawide	$4.40	$5.50	$7.75	$9.35	$11.60
Local	1.97	2.53	2.85	4.98	6.57
Connection Charge (Internal)[1]	$1,610	$2,315	$3,325	$4,765	$6,845
Service Charge - De-Escalated	$4.33	$4.08	$4.02	$4.06	$3.85
Revenues					
Subareawide Service Charges	$298,000	$423,000	$ 800,000	$1,181,000	$1,824,000
Local Sewerage Service Charges	133,000	195,000	294,000	629,000	1,033,000
Equalization Compensation	--	--	--	--	--
Total Revenues	$431,000	$618,000	$1,094,000	$1,810,000	$2,857,000
Expenses					
Subarea Expenses	$298,000	$423,000	$ 800,000	$1,181,000	$1,824,000
Internal Sewerage O & M	47,000	69,000	104,000	222,000	365,000
Customer Service	86,000	125,000	190,000	406,000	667,000
Total Expenses	$431,000	$617,000	$1,094,000	$1,809,000	$2,856,000

[1]Represents the level of charge to finance local benefit improvements. The revenue from this charge is not shown on this table.

which reduces the service charge by 40 percent. The offsetting cost to the City is an increase of 5 percent. The equalization method is in effect an approach to regionalization and is comparable to the rate structure that would evolve using a Metro, but without the delays and costs of forming a Metro. The equalization method is suggested for consideration by the agencies involved. Resolution of this methodology is one of the first hurdles to forming the cooperative relationship between agencies necessary to the physical, institutional and financial implementation of the suggested plan.

The Suggested Coordinated Plan for City-North Spokane Subsystem

Under the suggested institutional plan the City becomes the lead agency in owning and operating the treatment facility. Due to the physical location of much of the conveyance system within the city limits and the need to coordinate parts of it with needed sewer improvements, the City should also own and operate those conveyance facilities within the City. The City would therefore provide the financing for these facilities not covered by grants through revenue bonds. The County would own and finance the conveyance system and pump stations outside the City as well as the trunks 12 inches and larger in the County service area. The County could finance these facilities directly through revenue bonds, or by repayment under contract to the City for financing by City bonds.

The County would have further duties as coordinator, operating agency and contracting party in agreements with the City. The County would take the lead in the formation of LIDs to finance and construct local collection sewers smaller than 12 inches. The County as lead agency for the facilities in County areas could either augment its own utilities operation and maintenance department or contract for the work with the City. Similarly for customer service, the County could either establish its own organization or contract for these services with the City.

Local Cost Considerations. The foregoing discussion about cost allocation of regional facilites is important in determining the level of monthly service charges. For the presently unsewered areas in North Spokane, there is the additional immediate concern for the funding of the connection charge for internal sewerage: for internal collection sewers less than 12-inch size. It should be recognized that this cost will have to be funded by methods other than those already discussed, namely by a utilities local improvement district.

The area as a whole requires an assessment bond issue in 1980 of $10,900,000 (at escalated 1980 price level) to construct local benefit sewers serving 6600 Equivalent Dwelling Units (EDU's). The bond service cost for 20 years at 8 percent is $1,110,000 per year or $168

per average EDU per year, which would appear on the tax bill. De-escalated to 1974 price level the cost is $114 per EDU per year. This calculated result is conservatively high based on EDU's served since the actual assessment will also cover vacant lots that benefit. The word average is emphasized since the actual individual assessment will depend upon application of an assessment formula to each individual parcel. The foregoing has assumed no offsetting aid through grants. A uniform policy relating to grants for this type of facility has not been established in the State of Washington.

Without offsetting grants, the ULID financing is feasible and at a typical cost level. Note that the financial impact of the ULID portion of the work is approximately twice that of the regional facilities paid for by service charge.

Individual dwellings presently using individual on-site disposal also face a capital cost not covered by any public agency, namely alterations to plumbing on private property to connect public sewers at the property line. These costs will be highly variable on an individual basis depending upon the location and elevation of the existing septic tank and its relationship to the proposed public sewer house lateral. This cost can be a significant amount and is a difficult added financial burden for the individual in addition to his share of the publicly owned facilities. Unfortunately, financing for the private share of sewerage facilities must remain a matter for the individual to work out through normal home improvement financing channels.

Financial Requirements for Spokane Valley

For the Spokane Valley, the suggested lead agency is the County as owner and operator of facilities for the subarea. Local improvement districts would be utilized to construct local benefit facilities. Since only county areas are involved, except for the minor exception of the Town of Millwood, there is no need to consider alternative cost allocation plans.

Capital and operation and maintenance (O&M) costs for the regional facilities for the Spokane Valley subsystem have been previously referenced in Tables 10-5 and 10-6 respectively. In a manner similar to that described above for the City-North Spokane subsystem, these costs are developed into financial requirements based on revenue bond financing by the County for regional use facilities and assessment bonds for local benefit facilities. The capital cost and O&M cost summaries for regional use facilities are shown in Tables 10-26 and 10-27. The capital cost summary for local benefit facilities is sum-

TABLE 10-28

CAPITAL COST SUMMARY FOR LOCAL BENEFIT FACILITIES
SPOKANE VALLEY SUBSYSTEM

Year	Escalation Index[1]	Internal Sewerage Facilities Cost[2]	Escalated Cost
1985	2.27	$32,453,000	$ 73,663,000
1986	2.44	507,000	1,237,000
1987	2.62	507,000	1,328,000
1988	2.82	507,000	1,430,000
1989	3.03	507,000	1,536,000
1990	3.26	1,726,000	5,627,000
1991	3.50	462,000	1,617,000
1992	3.76	462,000	1,737,000
1993	4.04	462,000	1,866,000
1994	4.35	462,000	2,010,000
1995	4.67	1,615,000	7,542,000
1996	5.02	582,000	2,922,000
1997	5.40	582,000	3,143,000
1998	5.81	582,000	3,381,000
1999	6.24	582,000	3,632,000
2000	6.71	807,000	5,415,000
Subtotal		$42,805,000	$118,086,000
2001	7.21	486,000	3,504,000
2002	7.75	486,000	3,767,000
2003	8.34	486,000	4,053,000
2004	8.96	486,000	4,355,000
Total		$44,749,000	$133,765,000

[1]As a financing safeguard, costs are escalated to year shown.
[2]Does not include trunks and sewers 12" and larger in diameter, force mains and pump stations.

TABLE 10-29

SUMMARY OF FINANCING
SPOKANE VALLEY SUBSYSTEM

Regional Facilities	Escalated Costs	Year	State & Fed. Grants	Net Local Costs
Treatment plant	$ 9,336,000	1985	$8,402,000	$ 934,000
Disposal outfall	1,708,000	1985	1,537,000	171,000
Trunks, interceptors	20,734,000	1985	--	20,734,000
12" and larger, force	2,654,000	1990	--	2,654,000
mains, pump stations	4,077,000	1995	--	4,077,000
	3,335,000	2000	--	3,335,000

Bond Sales Necessary		
Year	Bond Sale Amount[1]	Average Annual Bond Service[2]
1985	$24,025,000	$2,062,000
1990	2,920,000	251,000
1995	4,485,000	385,000
2000	3,670,000	315,000

Local Benefit Facilities	Cost in 1974	Customers Benefiting (EDU's)	Cost Per User Benefited[3]
Gravity sewers less than 12" ϕ and side sewers	$42,805,000	28,390	$1,508

[1] Based on net local cost plus about 10% reserve funds and issuance costs.
[2] Based on 25 years at 7%.
[3] Based on 1974 dollars. Escalate at inflation rate and collect as a connection charge.

A test is made in Table 10-30 to determine if additional capital accruals are necessary for depreciation. The test indicates that there is no need for additional accruals since the payments on bond principal exceeds depreciation.

Subarea expenses and revenues are calculated in Table 10-31. The calculation shows an initial year service charge of $7.00 per month at 1974 price levels. This is 10 percent higher than that which results for the equalization cost method for County areas in the City-North Spokane subsystem of $6.37, also at 1974 price levels. As more customers are brought into the Spokane Valley system, the service charge could be expected to fall, reaching a level of $4.86 at 1974 price level in year 2000.

The service charge of course does not reflect the recovery of the capital cost for local benefit facilities built with assessment bond financing. To finance local benefit sewers for 20,020 EDU's in 1985,

TABLE 10-30

ESTIMATED DEPRECIATION COMPARED TO CAPITAL EXPENSE
SPOKANE VALLEY SUBSYSTEM

Facilities	Life for Expenditure Test[1] (Years)	Original Cost	Annual Depreciation
Starting 1985			
Treatment plant	30	$9,336,000	$311,000
Pump stations	30	610,000	20,000
Subtotal			$331,000
Starting 2000			
Pump stations	30	$1,080,000	$ 36,000
Total-Year 2000			$367,000

Year	Annual Depreciation	Less: Bond Principal	Additional Capital Accrual[2]
1985	$331,000	$ 385,000	--
1990	331,000	580,000	--
1995	331,000	905,000	--
2000	367,000	1,305,000	--

[1]Based on federal guidelines for capital recovery test.
[2]One measure of annual capital expense adequacy is to fund the higher of either annual depreciation or capital expenditures plus bond principal payments. Because capital expenditures for bond principal alone greatly exceed annual depreciation, no accrual to capital reserve is necessary during the period of this study.

TABLE 10-31

REVENUES AND EXPENSES--SPOKANE VALLEY SUBSYSTEM

	Year				
	1980	1985	1990	1995	2000
Number of Connections (EDU's)	20,020	22,130	24,215	26,510	28,390
New EDU's (Annual)	420	420	460	380	380
Service Charge (Monthly)	--	$13.80	$15.65	$18.60	$22.95
Connection Charge (Regional)	--	$450	$650	$935	$1,340
Connection Charge (Internal)[1]	--	$3,425	$4,915	$7,040	$10,120
Service Charge De-Escalated	--	$7.00	$5.93	$5.27	$4.86
Revenues					
Service Charge	--	$3,665,000	$4,548,000	$5,917,000	$7,818,000
Connection Charge (Regional)	--	189,000	299,000	355,000	509,000
Total Revenues	--	$3,854,000	$4,847,000	$6,272,000	$8,328,000
Expenses					
Treatment Plant and Outfall O&M	--	$1,314,000	$1,827,000	$2,517,000	$3,597,000
Internal Sewerage O&M	--	165,000	246,000	371,000	604,000
Customer Service	--	301,000	446,000	678,000	1,104,000
Equalization Compensation	--	900	800	700	600
Bond Service	--	2,062,000	2,313,000	2,698,000	3,013,000
Total Expenses	--	$3,842,900	$4,832,800	$6,264,700	$8,318,600

[1]Represents the level of charge to finance local benefit improvements. The revenue from this charge is not shown on this table.

assessment bonds totaling $74,000,000 (at 1985 escalated price level) would be required, without any credit for grant funding. As pointed out above, grant funding for this type of facility is highly uncertain at this time. The bond service cost for 20 years at 8 percent is $7,537,000 per year, equal to an average of $376 per year per EDU. In additional to the escalation from 1980 to 1985, the Spokane Valley cost is significantly higher than the North Spokane cost due to the absence of any existing local benefit sewers and the more scattered development pattern. The annual cost per average EDU, which would be collected as an addition to the property tax, is $191 per year when deescalated to 1974 prices. This cost is much higher than average. Although high, this is judged to be feasible on the basis that the average assessment in terms of 1974 price level is $2,100 per EDU or 12 percent of the average assessed valuation in Spokane Valley at $18,200 per parcel, also at 1974 price level.

Financial Impact of Possible Upgrade to Interpreted 1985 Standards

This study has developed and evaluated a suggested plan for possible upgrade of disposal standards from 1983 statutory requirements to an interpretation of requirements to meet the goal expressed for 1985 in Public Law 92-500.

It has been postulated that it is unlikely that a national effort beyond the 1983 standards of Public Law 92-500 would take place before 1990. Therefore, this study assumes implementation of upgrading to take place in 1990.

The suggested plan for upgrading of Plan A, the suggested plan to meet 1983 standards, is designated Plan D. Plan D provides for infiltration-percolation disposal to replace surface water disposal of Plan A for both the City-North Spokane and the Spokane Valley subsystems. Plan D is compatible with Plan A in that it utilizes the Plan A facilities and adds to them.

Impact on the City-North Spokane Subsystem. For the City-North Spokane subsystem, the estimated project capital cost for implementation of Plan D including conveyance and the infiltration ponds is $25,600,000, expressed at 1974 price level. No additions to the treatment plant itself are required since it has been assumed that denitrification will not be required at this specific infiltration-percolation site since access to the receiving aquifer is limited.

The forecast O&M costs in 1990 of the City STP with added facilities for infiltration-percolation disposal are $1,900,000 per year. This is less than the forecast O&M cost in 1990 with Plan A facilities for surface water disposal at $2,200,000 per year. The reason for the

reduction is elimination of the need for year-round phosphorus removal, with its 1990 chemical costs of $670,000, which more than offsets the added costs of O&M for added conveyance and ponds under Plan D.

If it is assumed that Federal and State grant funding are the same in 1990 as at present, the estimated project cost of upgrading at $25,600,000 is reduced to $2,600,000 local cost. These costs would be an addition to the capital costs for regional use. The 1990 escalated cost would be $8,476,000 and would add approximately $700,000 to the annual bond service cost. Under Plan A the average annual bond service cost in 1990 is $1,315,000 (equalized cost method). Under Plan D it would rise to approximately $2,015,000.

The annual regional O&M costs in 1990 under Plan A are $6,007,000. As indicated above, under Plan D the treatment and disposal O&M costs would experience a net decrease of $300,000 at 1974 price level. The decrease in terms of 1990 escalated dollars would be $792,000, making the annual O&M under Plan D equal to $5,215,000.

Since equalization compensation would remain unchanged, the Plan D regional expenses may be compared with Plan A as follows:

	1990 Expenses	
	Plan A	Plan D
Regional Operation & Maintenance	$6,007,000	$5,215,000
Equalization Compensation	372,000	372,000
Bond Service	1,315,000	2,015,000
Total Expenses	$7,694,000	$7,602,000

This indicates that the cost to locals under Plan D at 1990 would be no more than for Plan A and might even be less. Note that this is not at variance with the cost-effective analysis result which showed that Plan D was significantly more costly than Plan A. The apparently anomolous result in terms of cost to locals results from the offsetting of 90 percent of the capital costs by grants.

Impact on the Spokane Valley Subsystem. For the Spokane Valley subsystem, the estimated project capital cost for upgrading from Plan A to Plan D is $15,700,000 including conveyance, infiltration-percolation facilities and the addition of nitrification-denitrification to treatment.

The forecast O&M costs in 1990 of the upgraded Spokane Valley STP plus conveyance and ponds are $891,000 per year. Unlike the case for the City STP, these costs are significantly higher than the costs under Plan A conditions at $690,000. In this case the elimination of the costs for phosphorus removal chemicals at $144,000 per year is more than offset by the addition of operating costs for nitrification-denitrification at $220,000 per year.

Again assuming future Federal and State grant funding in 1990 comparable to the present, the estimated project cost of upgrading at $15,700,000 results in a local cost of approximately $1,600,000. The 1990 escalated local cost then becomes $5,216,000 and would add approximately $450,000 to the annual bond service cost. Under Plan A the average annual bond service cost in 1990 is $2,313,000. Under Plan D it would rise to $2,763,000.

The annual O&M costs under Plan D are shown above to increase $201,000 at 1974 price level. This increase is equal to $531,000 at 1990 escalated dollars. The Plan A O&M costs for 1990 are $1,827,000. Under Plan D these costs would rise to $2,358,000.

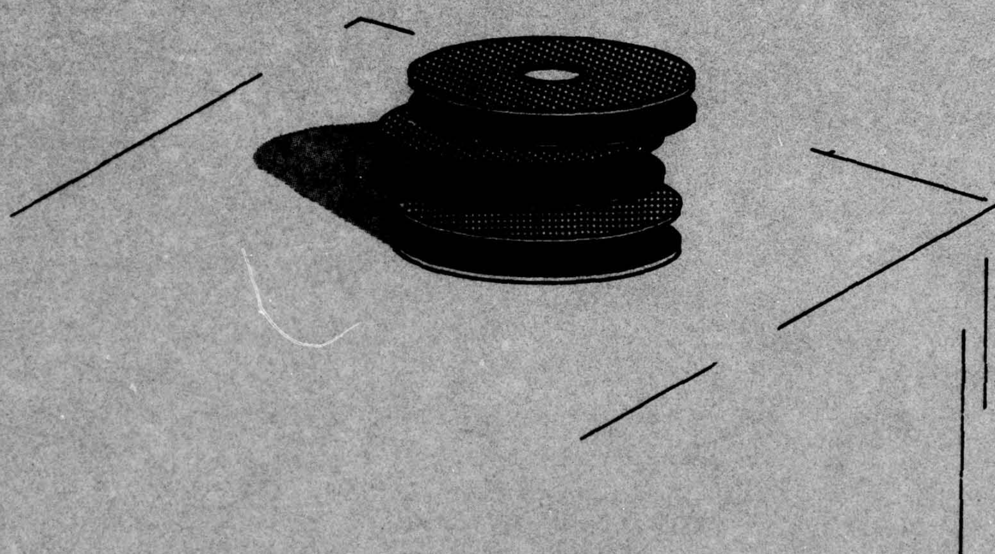
Other system expenses for internal sewerage O&M, customer service and equalization compensation would remain unchanged at $692,800 for 1990. Thus Plan A and Plan D expenses at 1990 can be compared as follows:

	1990 Expenses	
	Plan A	Plan D
Regional Operation & Maintenance	$1,827,000	$2,358,000
Unchanged Elements of Expense	692,800	692,800
Bond Service	2,313,000	2,763,000
Total Expenses	$4,832,800	$5,813,800

Unlike the City-North Spokane subarea, the Spokane Valley subarea would experience a 20 percent increase in annual expense under the implementation of Plan D in 1990. The corresponding increase in the monthly service charge would also be approximately 20 percent, raising the de-escalated service charge for Plan A in 1990 at $5.93 to approximately $7.12 for Plan D at 1990. This is high but not infeasible. As shown above, the internal sewerage cost remains the primary factor in financial feasibility for the Spokane Valley.

Financial Considerations for Incremental Development

The availability of grant funding may well be the determining factor in the schedule of implementation of wastewater management plans. In particular, it may be feasible to implement extensive internal sewerage systems costing tens of millions of dollars only in increments spread over a number of years. Since the size of such increments depends upon factors which cannot be foreseen, it is futile to develop specific step wise plans. The important consideration is that incremental construction be recognized in the formulation of financing and revenue plans. Certain plan elements such as an outfall sewer, are not feasibly done piecemeal since they must function as a whole. This will mean that initial stages may have high costs relative to the initial service areas. New definitions of benefit or potential benefit may have to be developed to provide a sufficiently broad revenue base for early stages of implementation.



SECTION 11

SIMULATION MODEL

11. Simulation Model

Introduction

A requirement of the study is the development of a mathematical model capable of simulating the hydrologic and water quality response of the study area. The simulation model is to have two roles: one, as a tool in this study and two, as a tool for ongoing research after completion of this study.

The role that the simulation model is to perform in this study is that of providing information about the response of the water environment to hypothetical changes. These data are to be used as guides in the decisionmaking process of selecting action plans for wastewater management.

Prior to inception of the study, a screening was made of available computer software which had the capability of providing hydrologic and water quality simulation for generalized watersheds. The Hydrocomp Simulation Programming was selected as the most appropriate base for developing a simulation specific to the watershed of the study area. The Hydrocomp Simulation Programming (HSP) is proprietary software which is the property of Hydrocomp, Inc., Palo Alto, California. HSP consists of algorithms for the calculation of the hydrologic cycle processess onto which other algorithms are superimposed for the chemical and biological processes occurring on land surfaces and in streams and impoundments. The algorithms are general for any watershed. The simulation is made specific by the insertion of a data base specific to a watershed followed by a calibration process.

Manipulation of the large masses of data utilized through the complex algorithms of the simulation requires the use of a very large digital computer. The hardware selected for the study was provided by McDonnel Douglas Automation Company (McAUTO) of St. Louis, Missouri. After completion of the production runs for this study, the data base is stored on magnetic tape. In the future it may be reactivated by loading into any compatible computer. Due to the proprietary nature of HSP it may be used only under contractural arrangement with Hydrocomp, Inc.

The Simulation Process

The HSP simulation process uses, as input data, meteorological data which are reacted with certain land parameters such as slope and perviousness to develop streamflows. The meteorological data categories

utilized are: precipitation, temperature, evaporation, solar radiation, dewpoint, cloud cover and wind velocity. The HSP simulation also uses meteorological data as the primary determinative force in processing chemical and biological activity, thus providing a water quality simulation specific to the input meteorological data and the corresponding hydrologic events. The HSP simulation is an iterative process working in one-hour steps. The result is a dynamic simulation in one-hour steps of hydrologic and water quality events corresponding to input meteorological conditions.

Basic to the utilization of this technique as a forecasting tool is the assumption that historical meteorological conditions are a sample of future meteorological events. Forecast performance under selected conditions is judged against the background of those conditions applied to an appropriate statistical or specific sample of historical meteorological conditions. The response of the simulated watershed to changed point source pollution loads can be demonstrated as responses under a selected period of meteorological history, as for example a dry year.

An important characteristic of the Spokane River system is the significance of groundwater interflow to the hydrologic regime. There are large interflows involving waters originating outside the basin as well as from precipitation in the basin. The HSP simulation has the capability of incorporating these interflows.

The net result of the simulation process is a tool with the capability of producing, as output for any period for which complete meteorological data is available, an hour-by-hour response by hydrologic and water quality events to a given set of pollution conditions.

Specific Simulation Conditions

The selected extent of the simulation is defined by the watersheds tributary to the Spokane River from the Idaho boundary to Long Lake Dam, the Little Spokane River and Hangman Creek. The watershed of the Spokane River in Idaho is not simulated from meteorological data; instead, the entering flow and quality of the Spokane River are provided as input to the simulation process. Stream flow records are available for periods corresponding to the periods for which meteorological data are available and are input as a data file. A special subroutine using meteorological input provides a temperature and dissolved oxygen (DO) file for the incoming river. Other water quality parameters are developed as an input file.

Another special condition of the watershed is the interchange of groundwater with the Spokane Valley aquifer. Since this groundwater stream originates outside the simulation boundary, it is not derived from meteorological data but must be provided as a separate input file. Available data from USGS studies make it possible to generate such a file for net additions to the Spokane and Little Spokane Rivers.

The points selected for water quality print-outs are as follows:

1. At the outlet of Long Lake
2. At three depths in Long Lake
3. Spokane River above the Little Spokane Confluence
4. Spokane River above the Hangman Creek Confluence
5. Spokane River at the east city limits
6. Little Spokane River at the mouth
7. Little Spokane River at Dartford
8. Hangman Creek at the mouth

Water quality parameters selected for simulation are listed below:

1. Dissolved Oxygen
2. Biochemical Oxygen Demand
3. Temperature
4. Total Dissolved Solids
5. Total Coliform
6. Fecal Coliform
7. Algae (Chlorophyll A)
8. Zooplankton
9. Orthophosphate
10. Potential Phosphate
11. Nitrate
12. Nitrite
13. Ammonia
14. Organic Nitrogen
15. Conservatives

The simulation model processes heavy metals as conservatives; as non-reacting pollutants. All the listed parameters are not selected for print-out at all locations for all runs.

The study area is subdivided into four subareas corresponding approximately to Water Resource Inventory Areas (WRIA) as follows:

1. Area 700, UPPER SPOKANE, is all of WRIA 57 downstream from USGS gage number 4195 at Liberty Bridge.

2. Area 500, LITTLE SPOKANE, is all of WRIA 55.

3. Area 600, HANGMAN, is all of WRIA 56 plus the rest of the natural tributary area in Idaho.

4. Area 400, LOWER SPOKANE, is all of WRIA 54 upstream from Long Lake Dam.

The simulation process can be carried out separately and independently for areas 500, 600 and 700. The simulation output of these three independent subareas becomes input to the simulation process for subarea 400.

Basic Data Input

Meteorological data were obtained from the National Oceanic and Atmospheric Administration (NOAA) largely in magnetic tape form for the period January 1953 through October 1973. The taped meteorological records have data gaps and contain errors and extraneous digits. The HSP program cannot accept the tape records due to these errors and omissions. The meteorological tapes, as received from NOAA, must be printed out and rectified manually. The rectified data are stored by the LIBRARY module of HSP and become a key element of the data base. Portions of this extended record can then be selected as appropriate to calibration and production runs.

In addition to the meteorological data, the basic data input includes land characteristics and the above mentioned boundary input files for the Spokane River and the Spokane Valley groundwater. The Spokane River file is complete and serves as input for the 1968-1969 period selected for production runs and the 1973 calibration period including an hourly file of temperature and DO as generated from a special routine.

Calibration

The model is calibrated in two steps, first for hydrologic simulation and then for water quality simulation output. The hydrologic calibration is itself broken down into elements corresponding to the subareas against the available USGS gage records as indicated below:

Area	Stream	USGS Gage Number
500	Little Spokane River	4310
600	Hangman Creek	4240
700	Spokane River	4225
400	Spokane River	4330

Before water quality calibration is possible, additional specific point source pollution input data are required corresponding to the calibration period. For this purpose point source pollution files are created as input to represent existing conditions:

1. Municipal Sources

    a. City STP
    b. Deer Park STP
    c. Tekoa STP

2. Industrial Sources

a. Hillyard Processing
b. Kaiser Aluminum, Trentwood
c. Spokane Industrial Park
d. Culligan Soft Water
e. Kaiser Aluminum, Mead

A major industrial point source, Inland Empire Paper, was closed by a strike from June prior to and through the calibration period and, therefore, is not included for calibration purposes. The load from this source is, however, included with actual production simulation runs.

In order to provide synoptic data of all the quality parameters being simulated, a special water quality sampling was developed and implemented covering a 48-hour period, noon 18 September 1973 to noon 20 September 1973. Samples were taken at four-hour intervals at ten river locations, at three depths in Long Lake and of the City STP effluent.

These data were the primary basis of calibration at all locations except Long Lake. The slow rate of chemical and biological response of Long Lake, compared with the river locations, indicated that the longest possible dynamic comparison period would provide superior calibration. For this purpose the work done by Dr. Raymond Soltero and associates over the entire summer of 1973 was utilized. The 18-20 September sampling in Long Lake corresponded to a location used by Dr. Soltero and was actually carried out under his direction to assure that the data was compatible with his long-term studies.

The water quality calibration process is an iterative process in which simulation runs are made and the output compared with actual observed conditions. In this case, the simulation runs are begun in June 1973 and run through the summer season to the observed condition beginning 18 September 1973. The simulation program has parameters that can be adjusted to make the simulation converge on the observed conditions. In general, satisfactory agreement was achieved in 10 to 20 iterations for most locations, but 30 iterations were required for Long Lake. As for hydrologic calibration, the procedure is to calibrate each of the subareas that are independent of each other and finally, the dependent subarea for which the other three provide input.

Since the simulation is dynamic, the conditions in nature at the time of calibration do not necessarily bias the simulation toward the calibration condition. That is, calibration in a year of intensive eutrophication will not necessarily bias the simulation to produce high results when the determining variables call for lower levels. The bias, if any, at other values of determining variables is unknown. The result is that the calibration has a known accuracy corresponding to the natural condition at the time of calibration whereas it may be more

or less accurate at other conditions. The natural conditions in 1973 were severe in that flows were extremely low and eutrophic conditions in Long Lake were extended and intense. This means that the simulation results are probably most accurately representative of periods when meteorological conditions and phosphorus loading correspond to those which produced severe eutrophic condition results. Until another calibration run is made for less severe meteorological or loading conditions it would not be known whether the results would be equally or less accurate. Less severe meteorological conditions occurred in 1974 but lower phosphorus loading will not be achieved until 1977.

Since Long Lake is a focus of interest in this study, the calibration results for that location are discussed to give a better understanding of the strengths and limitations of the simulation process for use in interpreting simulation of forecast conditions.

The simulation sees Long Lake as a body of water consisting of three layers: a top layer 0 to 5.5 meters depth, a middle layer 5.5 to 13.4 meters depth and a bottom layer 13.4 meters depth and below. The simulated quality for each layer is reported as the mean over the entire depth of the layer. At the sampling location, the lake is approximately 26 meters deep and the sampling depths are 1 meter, 15 meters and at the bottom. The simulation treats the entire extent of the lake in each horizontal stratum as a fully mixed homogeneous unit. Soltero's data for different locations on the lake show that this is a reasonable approximation for much of the year. Long Lake becomes strongly stratified as the summer progresses until a date late in September when turnover usually takes place, after which the lake becomes relatively well mixed. The calibration period does not extend to the turnover date since the lake was still stratified 18, 19 and 20 September during the special sampling.

The parameters of primary interest in Long Lake are temperature, dissolved oxygen, chlorophyll A and orthophosphate. The calibration significance of these four parameters is discussed briefly below and shown in Figures 11-1 through 11-4.

Temperature. Simulation is good in all layers until late in September. At that point the model starts cooling the top layer faster than nature whereas the middle layer is warmer. These deviations are only of the order of 1-1/2°C, but they are significant to the turnover mechanism. A compromise has to be reached in the calibration process to retard the turnover process by control of the mixing coefficient between layers to achieve turnover at the correct time. It is inherent in the HSP simulation to input the stream entering the lake entirely in the top layer at all times. In nature this is not true at all times. As late fall approaches and the river cools, the incoming waters tend to sink into the middle layer. This simulated variation from nature is the cause of the temperature deviation.

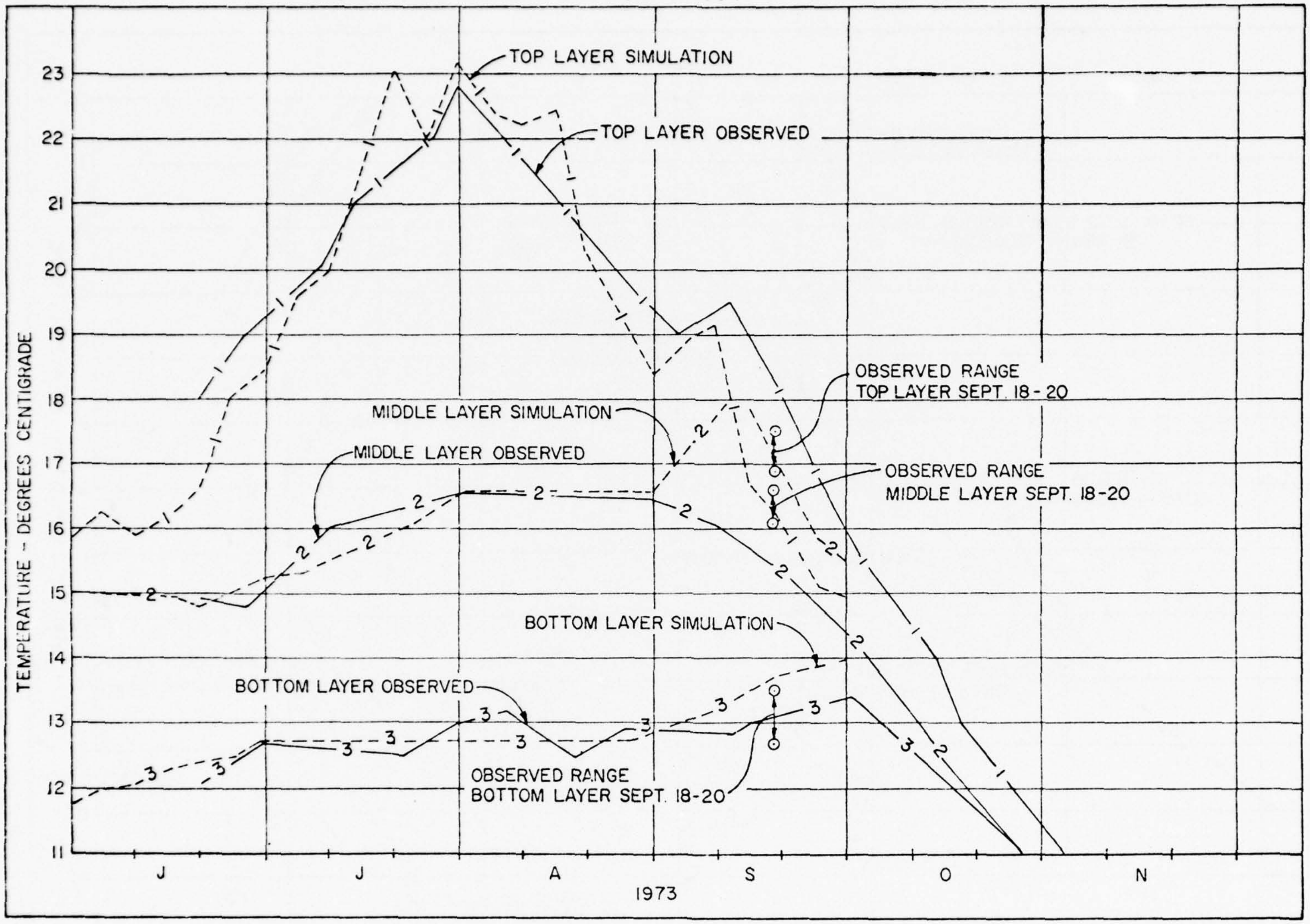


FIGURE 11-1 LONG LAKE CALIBRATION, TEMPERATURE

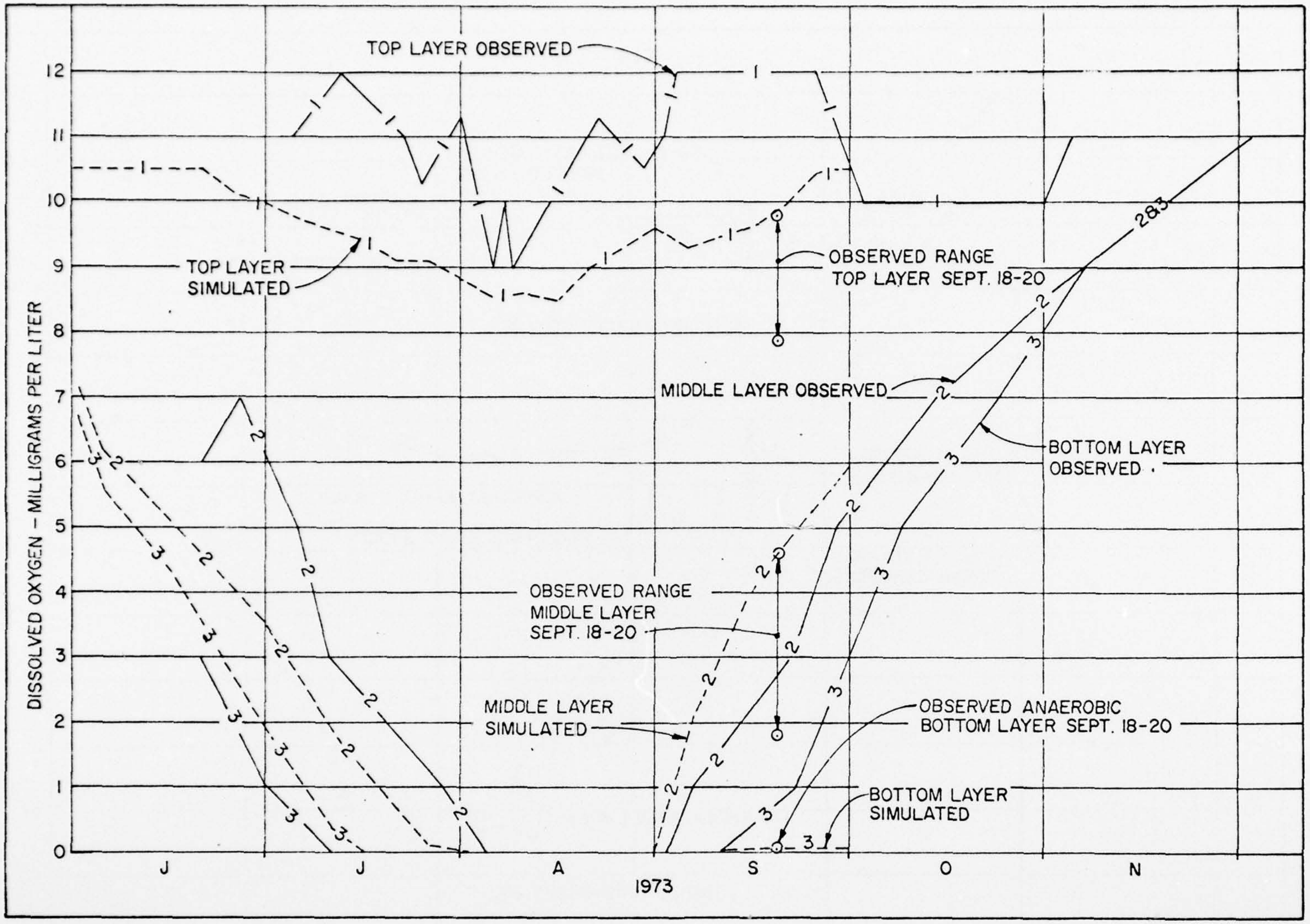


FIGURE 11-2 LONG LAKE CALIBRATION, DISSOLVED OXYGEN

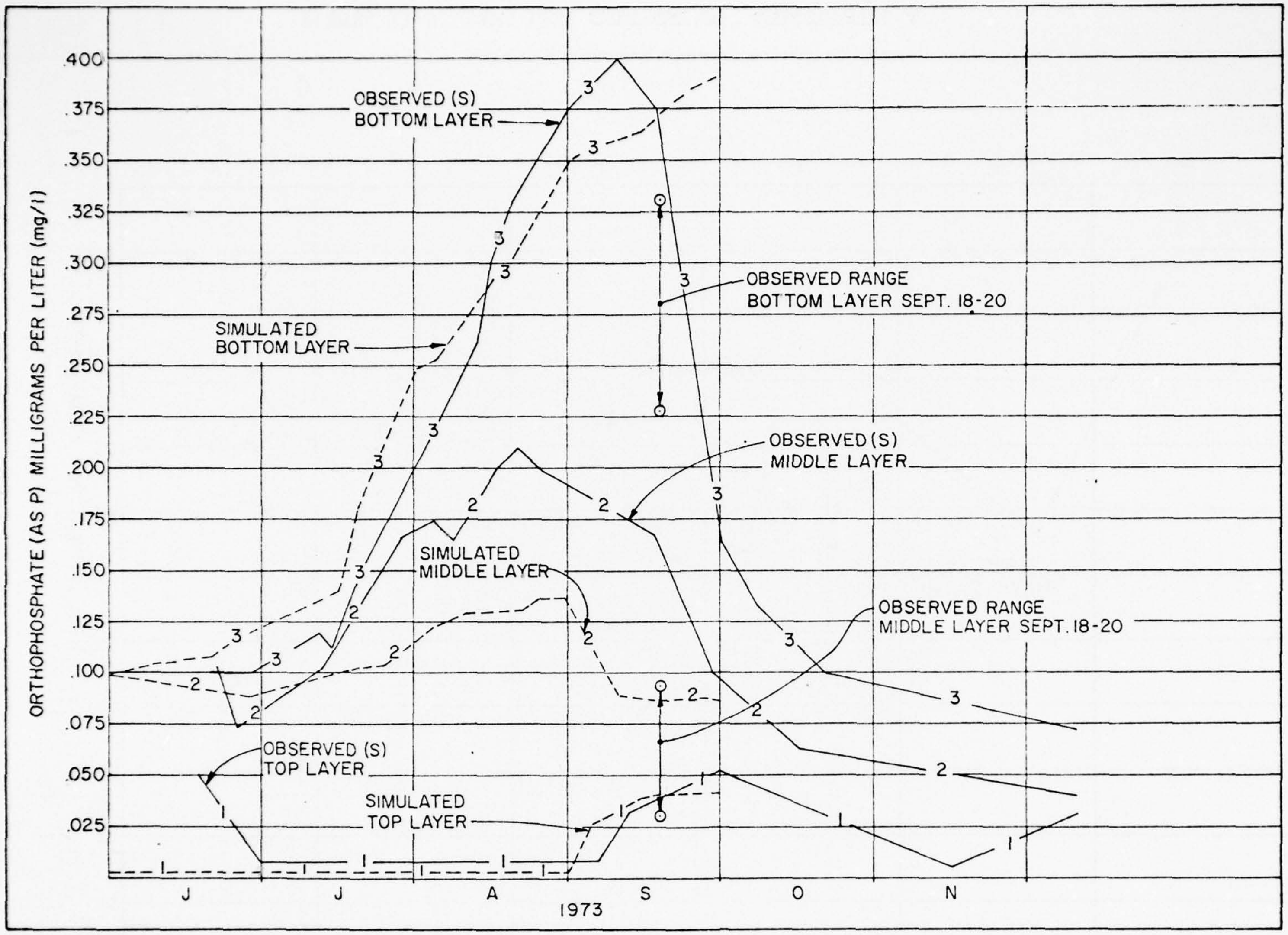


FIGURE 11-3 LONG LAKE CALIBRATION, ORTHOPHOSPHATE

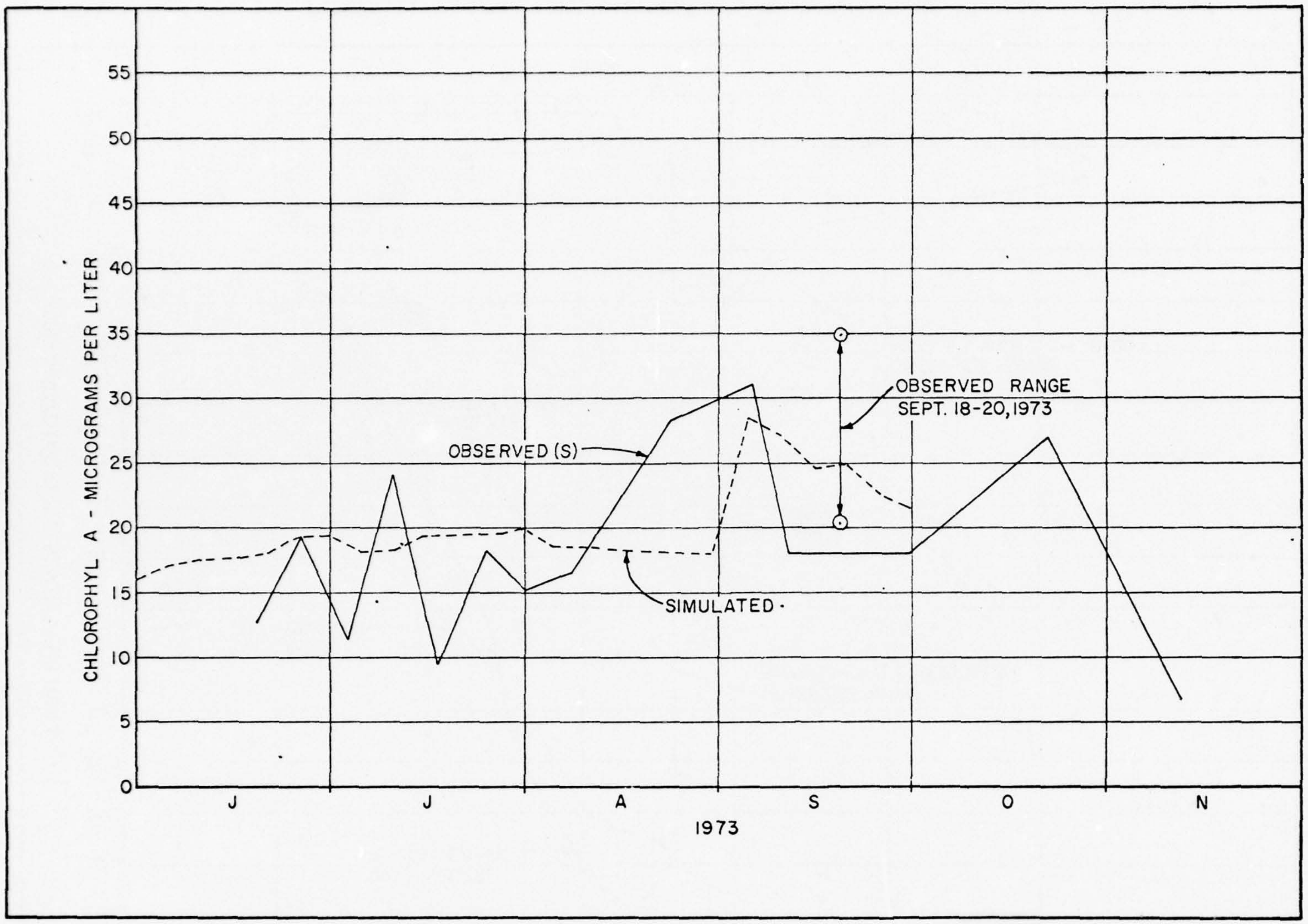


FIGURE 11-4 LONG LAKE CALIBRATION, CHLOROPHYLL A

Dissolved Oxygen. The DO of the lower layers is of primary concern. Anaerobic conditions in the bottom layer particularly are of concern since that condition permits activity to release phosphorus from the bottom sediments into solution. The simulation correctly identifies the date of the onset of anaerobic conditions in the middle and bottom layers under present conditions. The simulation overshoots the anaerobic period in the bottom layer at the end of the season by two weeks due to the compromise setting of mixing coefficients noted above. Top layer DO simulation is approximately at saturation. This is lower than the supersaturated condition detected at 1 meter depth by sampling but probably correct for the mean over the top 5.5 meters.

Chlorophyll A. The simulation shows relatively little variation in level through the summer, but gives a level that appears to be close to the mean of the wider swings observed in nature. There is an approximate two-week cycle in the June-July period of wide variation in the natural level that is not reflected in the simulation.

Phosphate. As with DO, the primary interest for phosphate is in the lower layers. The surface layer is kept near exhaustion by the algal activity throughout the stratified season. The simulation correctly identifies the date at which increased levels start to reach the surface layer in September. Simulation in the middle layer is the same as observed at both ends of the season, but runs low during the buildup in mid-season. Bottom layer simulation of amounts being released by anaerobic activity is good except that the cessation of activity is delayed by a couple of weeks, again by the compromise in mixing. Bottom simulation reaches the same levels as observed, approaching 0.4 mg/l toward mid-September.

Production Run Formulation

With the model loaded with meteorological data, land parameters and boundary files and with calibration satisfactorily completed, the model is ready to simulate selected forecast conditions. The first condition selected for simulation is the condition with all point sources of pollution removed, designated herein the no-point-source (NPS) run.

The purpose of the NPS run is to establish background conditions - the best water quality condition that could be expected if the goal of zero pollution were achieved within the study area. The NPS run is a simulation under the selected sample meteorological conditions for the period May 1968 through September 1969 with all point sources removed. This period is selected for both production runs because it contains examples of both wet and dry years. The water quality entering from Idaho both as surface water and as groundwater is assumed to be the same as presently observed, its primary deficiency being the bacteriological quality of the surface water.

The alternative wastewater management plans considered range from systems consisting entirely of surface water discharges to systems consisting entirely of land application to irrigation. Those plans consisting entirely of land application are substantially represented in simulation by the NPS run. The impact on surface waters through groundwater interchange from irrigation alternatives is judged to be negligibly small for the irrigation application criteria used. There would be a more significant impact through groundwater interchange for the rapid percolation alternatives, but limited to the soluble salts which, with the exception of nitrates, are not a pollution threat here. Phosphates would be removed by soil reactions and coliforms by filtration through the soil. Therefore, the rapid percolation alternatives are likewise substantially represented by the NPS run.

The surface water disposal alternatives are those which will impact the surface water quality. The suggested plan, Plan A, consists of two surface water disposals, one of which has strong probability of early implementation. Although the second surface water disposal for Spokane Valley under Plan A probably will not be implemented early, it is prudent to include it in the evaluation of impact. Therefore, the second production run is selected to represent the total Plan A for both subsystems at year 2000 conditions meeting 1983 disposal criteria. This run is designated the year 2000 run. The two runs, NPS and year 2000, provide a bracketing of the best possible surface water quality condition and the most severe impact possible under 1983 standards.

Further considerations for the year 2000 run include selection of seasonal phosphorus removal for the purpose of evaluating its impact and determining if there is need for year-round removal. The season selected for phosphorus removal is 1 May to 15 October. The potential for development of ammonia toxicity conditions and means for its alleviation is also investigated by providing a two-week period of nitrification operation of the City STP for comparison. The importance of close control of bacterial levels in treated effluent is investigated by providing for comparison a two-week period in which quality is allowed to deteriorate to the 7-day maximum allowed by secondary treatment guidelines.

All of the foregoing considerations are recognized in the compilation of the point source input files for the year 2000 run. The following point source files comprise the year 2000 pollutant load.

1. Municipal sources, all assumed to be effluent from secondary treatment plants to 1983 standards.

    a. City STP with seasonal phosphorus removal and nitrification and bacterial test periods. Flow 40 mgd equal 62 cfs.
    b. Spokane Valley STP with seasonal phosphorus removal and bacterial removal test period but without nitrification test. Flow 10 mgd equal 15.5 cfs.

c. Deer Park STP, without phosphorus removal or tests. Flow 0.22 mgd equal 0.35 cfs.
d. Tekoa STP, without phosphorus removal or tests. Flow 0.10 mgd equal 0.15 cfs.

2. Industrial sources, forecast.

a. Spokane Valley process flows, 15.15 mgd equal 23.4 cfs.
b. Spokane Valley cooling flows, 17.5 mgd at 1.5°C rise, returned surface water.
c. North Spokane process flows, 0.48 mgd equal 0.74 cfs.
d. North Spokane cooling flows, 4.33 mgd equal 6.7 cfs at temperature 18°C, from groundwater source.

Production Run Results

Print-outs of the NPS and year 2000 runs were made for each entire 17 months simulation period at six-hour intervals and for the following locations:

1. Upper Spokane, Subarea 700, WRIA 57.

a. Vicinity of University Road extended, about one mile east of Millwood.
b. At east city limits.
c. Above Hangman Creek confluence.

2. Hangman Creek, Subarea 600, WRIA 56.

a. At Tekoa.
b. Above Rock Creek confluence.
c. Mouth of Rock Creek.
d. Vicinity of Gibbs Road extended.
e. At Minnie Creek confluence.
f. At mouth.

3. Little Spokane, Subarea 500, WRIA 55.

a. Mouth of east branch above Milan.
b. Mouth of west branch above Milan.
c. Vicinity of Chattaroy on main stream.
d. Mouth of Dragoon Creek.
e. Mouth of Deep Creek.
f. Mouth of Peone Creek and mouth of Deadman Branch of Peone Creek.
g. Main stream at Deep Creek-Peone Creek confluence.
h. Mouth of main stream at the Spokane River.

4. Lower Spokane, Subarea 400, WRIA 54

   a. Above the Deep Creek confluence, upstream from Nine Mile Reservoir.
   b. Above the Little Spokane confluence at Nine Mile Dam.
   c. In Long Lake at a point approximately 4 miles upstream from the dam.
      (1) In the surface layer.
      (2) In the middle layer.
      (3) In the bottom layer.
   d. Below Long Lake Dam

The quality parameters made available in the print-out of each of the stream locations are as follows:

1. Dissolved oxygen.
2. Temperature.
3. BOD.
4. Total dissolved solids.
5. Total coliform.
6. Fecal coliform.
7. Orthophosphate.
8. Potential phosphate.
9. Nitrate.
10. Nitrite.
11. Ammonia.
12. Organic nitrogen.
13. A conservative.

For the Lower Spokane subarea only, which includes the City STP input and Long Lake, the index parameter for algal biomass, chlor. A, is also provided.

Potential phosphate represents the phosphorus associated with the living biomass and with the BOD. It is the simulation program's parameter to maintain the phosphorus budget. Total phosphorus is the sum of orthophosphate and potential phosphate. The conservative is an index of proportionality that would show the concentration of a non-reacting parameter as it progressed through the system.

The print-out also provides the mean daily streamflow in cfs at each location listed above.

Evaluation of Results, Spokane River and Long Lake

Some of the most significant results of the simulation have been summarized above under performance evaluation for the suggested plan. Necessarily, some of that material is reproduced here to make this summary complete.

Table 11-1 contrasts the NPS and year 2000 water quality conditions for significant locations on the Spokane River including Long Lake. Two specific dates are selected late in the summer season for the meteorological and flow conditions of 10 August 1968 and 25 August 1968. These dates are selected as representative of the most critical time of the year for both the river and Long Lake and for a year of low runoff. One date is selected in the first half of August to demonstrate the results of nitrification at the City STP and normal bacterial removal. The date in the second half of August is in the period when the City STP input file is without nitrification and has poorer bacterical control. It should be noted that the Spokane River flow on 10 August 1968 at 919 cfs (NPS conditions) is only 7 percent above the calculated 7-day 10-year low of 860 cfs.

The first two columns of data in Table 11-1 contrast performance on the Spokane River above the Hangman Creek confluence. This location shows the impact of the discharge from the Spokane Valley municipal treatment plant and the Spokane Valley industrial loads. Although phosphorus removal is taking place, there is significant biological activity taking place at year 2000 conditions in response to the relatively small phosphorus additions. This activity affects the performance of the river with respect to DO. The simulation shows an increase in DO at year 2000 over NPS conditions, indicating that the impact of the biological activity in adding oxygen is greater than the effect of the added BOD in depressing the oxygen supply. The data in Table 11-1 are for 1800 hours, 6 p.m., at the end of the strong daylight. The simulation six hours later at midnight shows that the DO by then has fallen to below NPS levels, demonstrating that the biological activity is indeed responsible. At midnight, however, the reduction in DO although measurable is not significant.

The high bacterial counts in the Spokane River at the boundary tend to mask the impact of the Spokane Valley STP effluent. Consideration of the dilution of the Spokane Valley STP effluent of 60 to 1 on 10 August and over 100 to 1 on 25 August explains the insignificant impact. The amount of ammonia does not reach dangerous levels below the Spokane Valley STP without nitrification due to the high dilution ratio.

The impact of the industrial cooling waterload is shown to be only 0.1°C. The impacts of sunlight and groundwater interchange are much more significant in this reach. There is an approximate 2° drop from the boundary condition due to groundwater interchange and a diurnal change of approximately 3° due to sunlight.

In general, it can be concluded from the simulation that the combined Spokane Valley STP and industrial loads would not degrade the river below Class A standards.

The second set of columns in Table 11-1 contrasts conditions in the Spokane River downstream from the City STP. Here again, the DO is raised by the biological activity in daylight more than it is

TABLE 11-1

SIMULATED WATER QUALITY

Meteorological Event				Reach 730 Spokane River Abv. Hangman Cr. Confluence		Reach 430 Spokane River Abv. Little Spk. Confluence		Long Lake-Reach 440 Top Layer		Long Lake-Reach 440 Middle Layer		Long Lake-Reach 440 Bottom Layer		Reach 450 Leaving Long Lake	
Date	Time	Parameter	Units	NPS[1]	YR 2000[2]	NPS	YR 2000	NPS	Yr 2000	NPS	YR 2000	NPS	YR 2000	NPS	YR 2000
10Aug68	1800[3]	Dissolved Oxygen	mg/l	8.8	9.9	8.2	9.1	8.1	8.8	6.9	1.8	2.8	0.0	8.2	8.5
		BOD	mg/l	0.6	2.1	1.1	9.1	0.1	1.7	0.0	0.6	0.1	0.4	0.3	2.0
		Temperature	°C	18.5	18.6	20.9	20.8	20.9	20.9	15.0	15.2	10.2	10.3	22.0	22.0
		Total Coliform	org/100 ml	299	297	257	256	42	43	0.0	0.0	0.0	0.0	35	36
		Fecal Coliform	org/100 ml	6	11	5	9	1	1	0.0	0.0	0.0	0.0	1	1
		Orthophosphate	mg/l	.001	.015	0.0	.006	0.0	.001	.031	.064	.082	.133	.001	.001
		Pot. Phosphate	mg/l	.009	.026	.008	.069	0.0	.013	0.0	.005	.001	.003	.002	.015
		Total Phosphate	mg/l	.010	.041	.008	.075	0.0	.014	.031	.069	.083	.136	.003	.016
		Ammonia	mg/l	.006	.123	.013	.048	0.0	.005	0.0	.011	.005	.228	.004	.008
		Total Nitrogen	mg/l	.554	.825	.65	2.69	.44	.98	.33	.59	.50	.62	.46	.99
		Chlorophyll A	ug/l			3.5	48.5	.30	11.3	.10	4.2	.10	.60	.90	12.2
		Flow	cfs	919	957	1065	1106							1107	1107
25Aug68	1800[4]	Dissolved Oxygen	mg/l	9.5	10.1	8.9	9.7	8.5	9.2	6.8	.3	2.0	0.0	8.5	9.1
		BOD	mg/l	1.0	1.6	1.4	5.9	0.1	1.7	0.0	.6	.1	1.7	.2	1.8
		Temperature	°C	17.0	17.1	18.3	18.3	18.4	18.4	15.0	15.2	10.2	10.3	18.9	18.9
		Total Coliform	org/100 ml	468	467	412	412	87	87	0.0	0.0	0.0	0.0	77	77
		Fecal Coliform	org/100 ml	8	13	13	17	4	5	0.0	0.0	0.0	0.0	4	5
		Orthophosphate	mg/l	.003	.016	.001	.005	0.0	.001	.032	.076	.088	.198	.001	.001
		Pot. Phosphate	mg/l	.017	.023	.010	.045	.001	.013	0.0	.005	.001	.013	.001	.014
		Total Phosphate	mg/l	.020	.039	.011	.050	.001	.014	.032	.018	.089	.211	.002	.015
		Ammonia	mg/l	.010	.093	.012	.305	0.0	.013	0.0	.082	.007	.434	.003	.012
		Total Nitrogen	mg/l	.383	.566	.40	1.15	.41	.92	.32	.74	.53	.65	.42	.95
		Chlorophyll A	ug/l			4.6	29.5	.50	11.2	.10	4.1	.10	.60	.50	11.5
		Flow	cfs	1599	1638	1760	1801							1846	2109

[1] NPS = no-point-source simulation.

[2] Yr 2000 = simulation of year 2000 conditions with Plan A point sources for urban area.

[3] Last precipitation prior to 10 Aug 68 was 0.2 in. on July 19. Simulation between 1 Aug and 15 Aug has nitrification treatment for City STP point source.

[4] Last precipitation prior to 25 Aug 68 was 0.13 in. on Aug 23. Simulation between 15 Aug and 31 Aug does not have nitrification treatment for City STP and has coliform at 800 org/100 ml.

depressed by the added BOD. The biological activity as a result of added nutrients in combination with the highwater temperatures is very large. The chlor. A values at the low flow on 10 August reach 48.5 ug/l and the biomass has already utilized most of the added phosphorus as indicated by the drop of ortho P to 0.006 mg/l and increase of potential P to 0.069 mg/l.

With nitrification, ammonia is shown to be at a safe level of 0.048 mg/l but without nitrification at the higher dilutions which occur on 25 August, the ammonia reaches 0.305 mg/l, a level of concern.

The dilution for the City STP at year 2000 for the 10 August flow is approximately 17 to 1 and for 25 August 28 to 1. At these relatively low dilutions, the impact of bacterial pollution would be expected to be much greater than for the Spokane Valley STP. Again, however, the impact is masked by the high background levels. Purely on a dilution basis, the City STP additions should maintain the stream well within Class A standards even under less than optimum removal assumptions.

Immediately below the City STP at year 2000 it can be concluded that at summer low flow conditions there will be heavy biomass activity that will be visible, most prominently in Nine Mile Reservoir, and that there is a threat of ammonia toxicity without nitrification.

The water quality in the three layers of Long Lake and after leaving Long Lake is contrasted in the remaining columns in Table 11-1. Figures 11-5 and 11-6 show and contrast critical parameters for Long Lake in graphical form for the meteorological and flow conditions of 1968 and 1969, respectively.

Referring to Figures 11-5 and 11-6, the perfomance of Long Lake under NPS conditions can be observed. The first conclusion is that the temperature and stratification conditions are the same as presently observed. The wide range of temperature from 20°C at the surface to 10°C at the bottom provides strong forces to prevent mixing and to maintain stratification. Even at NPS conditions, this strong stratification results in very low DO conditions at the bottom, leaving little reserve to prevent going anaerobic with the addition of a small amount of BOD. The biomass is negligible throughout the summer at NPS conditions once the nutrients in the surface layer have been used up and the incoming supply falls with the reduction in flow. There are still algal blooms, at below nuisance levels, in the spring and at the fall turnover. Note that the amount of unused phosphorus in the lower layers at NPS conditions is about half of year 2000 conditions but still at significant levels. Only the lower temperatures and reduced sunlight, when the phosphorus from lower layers becomes available at turnover, prevent larger growths.

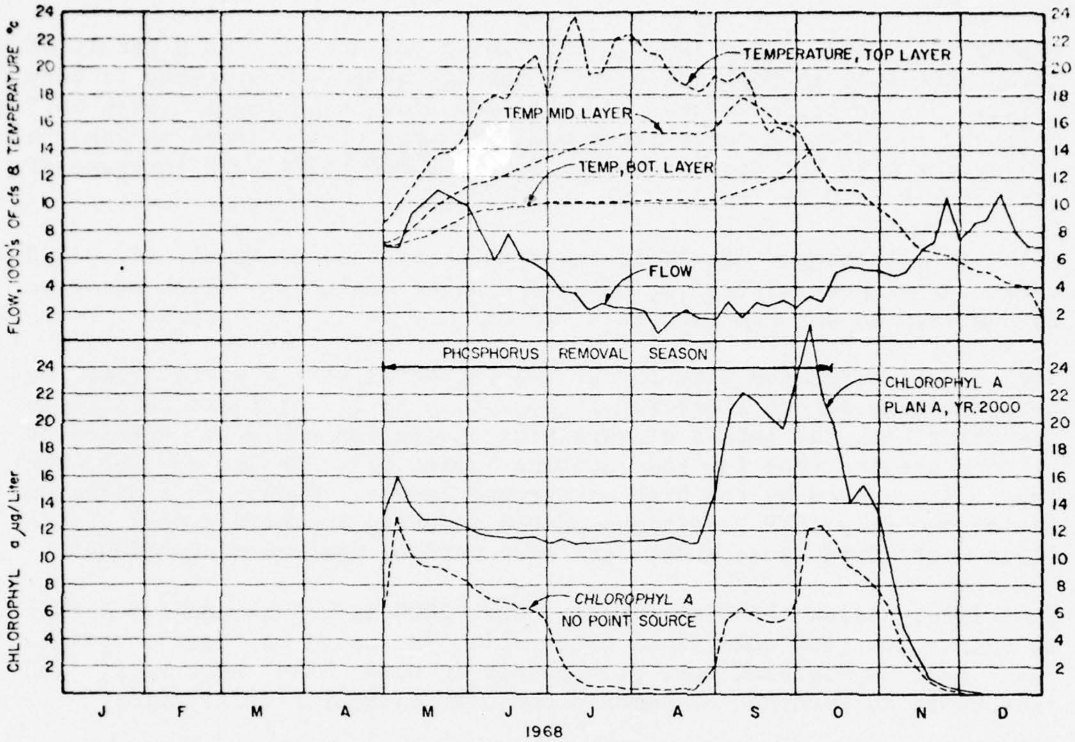


FIGURE II-5 LONG LAKE WATER QUALITY SIMULATION IN LOW RUNOFF YEAR

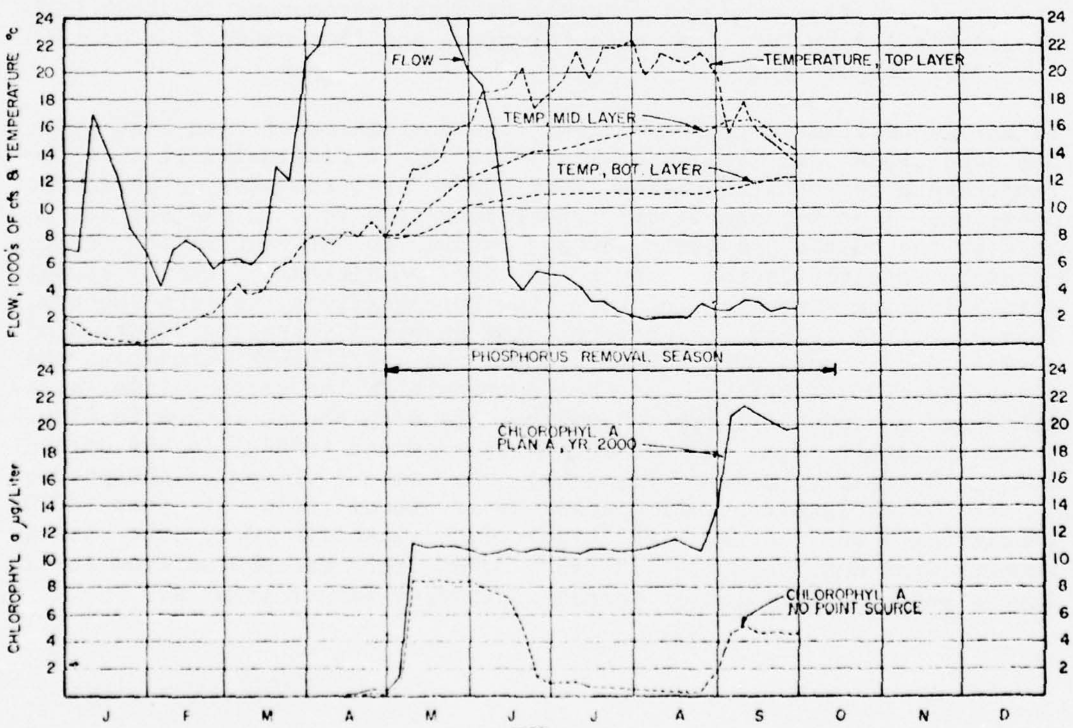


FIGURE II-6 LONG LAKE WATER QUALITY SIMULATION IN A HIGH RUNOFF YEAR

The addition of the phosphorus load forecast for year 2000 condition, even with phosphorus removal, is of the order 690 pounds per day. The present estimated load from the City STP with primary treatment and no phosphorus removal is of the order 2500 pounds per day. The expected load after completion of the proposed expansion and upgrade but with the 1975 flow is of the order 350 pounds per day. Background level in the Spokane River at mean summer flows of 1500 cfs is 120 pounds per day. The ratios of the NPS simulation condition to other conditions are shown below.

	Approximate Phosphate Loads Pounds Per Day			
Condition	Background	Point Source	Total	Ratio
No-point-source simulation	120	-	120	1.00
Year 2000 simulation	120	690	810	6.75
Present conditions	120	2500	2620	21.83
Present flow with 85% removal	120	350	470	3.92

The observed level of biomass under present conditions reached levels of 15 to 30 ug/l in the calibration period during a severe year for eutrophication. The simulated level under NPS conditions is less than 2 ug/l and is approximately 11 ug/l under year 2000 simulated conditions. The year 2000 simulation indicates that the reduction to a mean level of 11 ug/l for late summer would be a significant improvement over present conditions. The level is not reduced to the level generally accepted as satisfactory; namely, around 5 to 7 ug/l. The relation between phosphorus loading and biomass may not be linear from the NPS to present conditions. At the levels above the year 2000 simulation the utilization appears to be limited by other factors. If the relationship is close to linear below the year 2000 level, the expected performance in 1977 when the upgraded City STP is in service is around 7 ug/l. This would indicate that for average summer conditions quality would gradually decrease from around 7 to 11 ug/l as the total flows increased over the years.

Under year 2000 conditions the middle layer does not become anaerobic as it does at present but the DO at 1.8 mg/l is significantly below NPS conditions at 6.9 mg/l. The bottom layer does go anaerobic at year 2000 conditions during the first week in August. This is a significant improvement over present conditions in which the middle layer becomes anaerobic by the first of August and the bottom layer by mid-July.

At year 2000, the simulated phosphate concentration in the middle and bottom layers is 0.064 and 0.076 mg/l, respectively, on the 10 August and 25 August dates. These levels are about twice the NPS levels. Under present conditions the bottom layer levels have reached over 0.2 mg/l by early August on their way to highs of 0.4 mg/l in September. At year 2000, the simulated phosphate tops at 0.25 mg/l prior to turnover. Since under NPS conditions the bottom layer does not go

anaerobic, the maximum phosphate level is only 0.085 mg/l, which is about equal to the levels reached by year 2000 as the anaerobic period begins.

Since there are spring and post-turnover blooms under NPS conditions, similar blooms are to be expected under year 2000 conditions. This is borne out in the year 2000 simulations with the spring blooms not much higher than the NPS condition but with the post-turnover blooms approaching present conditions. High values, over 20 ug/l, are reached in September when the nutrient supply in the surface layer is increased by a small amount of mixing from the middle layer. The simulation provides for various degrees of vertical mixing between lake layers even when nominally stratified, a condition that also occurs in nature. The mixing coefficient is adjustable in monthly steps.

Immediately after turnover at the first of October, there is another jump in activity corresponding to the bottom layer nutrients being made available at the surface but temperature and sunlight conditions are deteriorating so rapidly that the activity begins to decrease at a high rate. When 15 October is reached, the temperature and light conditions have become so overwhelmingly important that the increased availability of phosphorus following cessation of removal has no significant effect in checking the fall in algae productivity. By the first weeks in November, the chlor. A levels have fallen to NPS levels despite incoming phosphorus levels of the order 3500 pounds per day.

In spring, the critical temperature and sunlight conditions are seen to operate in a similar manner. In the year 2000 simulation, with no phosphorus removal throughout April, there is no algal activity. Only after phosphorus removal has begun on 1 May does activity start as water temperatures begin to climb above 10°C. These results indicate that phosphorus concentration of the river as it enters Long Lake between 15 October and 1 May may not affect the eutrophic condition of Long Lake during the following summer. Refer to Section 9 for discussion of the possible significance to seasonal phosphorus removal.

Water quality of the reach below Long Lake is largely determined by the quality of the surface layer in Long Lake. This was evident from the calibration conditions and consequently reappears in the simulation. This result apparently derives from the construction of the outlet works of Long Lake Dam in which the penstock inlets are at a level corresponding to the upper part of the middle layer. (The top of the penstock is at 30 feet or less than 10 meters depth.)

Evaluation of Results, Little Spokane River and Hangman Creek

The primary function of the Little Spokane River and Hangman Creek simulations is to develop input to the main flow of the Spokane River. It should be kept in mind that both streams are calibrated to condi-

tions at the mouth only and that upstream points may therefore differ from actual conditions.

The Little Spokane River NPS and year 2000 simulations show deficiencies in total coliforms and DO. The coliforms originate from non-point sources and become a part of the background condition in the calibration process. The low DO conditions, between 7 and 8, occur only during part of the day and result from the simulation of very low flows. These apparent low DO conditions are judged not to be "real" for upstream reaches. The DO levels in the range 7 to 8 in the reach just before the confluence are real and the result of the large volume of groundwater interchange. There appear to be no deficiencies that are the result of point source loads.

The NPS and year 2000 simulation show no significant deficiencies in the Hangman Creek data in the absence of precipitation. The same limitations to accuracy of DO results at low flow also apply. The Hangman Creek quality, since the stream is so flashy, is heavily impacted by precipitation events and the accompanying washoff of non-point-source pollutants. Under these conditions high coliform counts result. The simulation process is not capable of dealing with the silt load of Hangman Creek.

Future Application of the Simulation Model

General. The calibration and production runs made under this study by no means exhaust the potential of this tool for planning, regulatory or research purposes. Some of the potential applications that are apparent at this time are explored briefly below. In addition there will be the unforeseen or unanticipated changes in conditions or regulatory requirements that will provide other opportunities for use.

Since the Corps of Engineers does not have an ongoing authorization or responsibility for either planning or regulatory functions at this location, it is evident that a local agency with appropriate authority and responsibility should consider becoming custodian of the tool for ongoing use. In addition to the obvious usefulness to DOE, the City should find high interest, particularly as related to the forthcoming combined sewer overflow abatement problem.

Statistical Evaluation. The trend in regulatory practice is to express requirements in statistical terms rather than a single fixed not-to-be-exceeded value. As requirements become more stringent, statistical expression is expected to be utilized to achieve these ends economically. Also, when regulatory requirements are set for urban runoff, they can hardly be expressed in other than statistical terms.

The HSP simulation, with its capability of developing responsive quality data over periods as long as available meteorological records, can provide the raw materials for statistical analysis. The HSP simulation does not in itself contain statistical analysis programming

but this is readily available from other software sources which can be utilized to analyze the HSP output stream. This project has provided the meteorological data for a 20-year period which may be used for future application of the model to develop valid statistical results.

Low Flow Augmentation. One of the most intriguing possibilities suggested by analysis of the initial production simulation runs, particularly evaluation of the NPS condition, concerns the possibility of controlling both quantity and temperature of flow. The quality simulation under these runs indicates that phosphorus may not be the sole limiting factor at all times in limiting biological activity within the rivers or Long Lake. Impoundment detention, temperature, lake stratification, radiation and other chemicals may be more critical factors under certain conditions. The consideration of control of riverflow and water temperature, which are discussed elsewhere as possible water quality management strategies, could be tested with the simulation model. It is possible to evaluate riverflow operating policies to determine the optimum procedure accounting for both water quality and power generation.

Urban Runoff. Since the HSP simulation generates surface runoff and pollutant loads from meteorological events with full recognition of the time functions of buildup and washoff of pollutants, it is ideal for evaluation of urban runoff impact. A simulation of urban runoff is included in both the NPS and year 2000 runs. This specific application, however, does not take full advantage of the model capability.

As presently incorporated in the model, urban runoff is the consequence of the amount of impervious area assigned to segments, which include the presently sewered urban areas. Both the volume and the quality of runoff from the urban portion under these conditions are inseparable from the remainder of the segment which is large compared with the urban area. This does not permit evaluation of urban runoff separately, its treatment potential or its impact on combined sewer overflows. The model has the capability of other modes of application, particularly through use of subroutines and side runs to meet these requirements. With the future advent of specific urban runoff guidelines from EPA or in anticipation of same, it would be justified to make these more refined approaches. The urban area could be deleted from the natural runoff reaches in which it occurs and a single separate reach could be created for the urban area. This separated reach could be processed separately from the remainder of the simulation area at greatly reduced cost and with output available for separate analysis or manipulation. The advantage of the separate side run to simulate urban runoff is that it can then be subjected to statistical analysis and to various treatment alternatives before being entered into the basin simulation as a point source. This is not possible if the urban runoff simulation is an integral part of basin simulation as at present.

There are no urban runoff data specific to Spokane or to a Spokane sequence of rainfall events. Only isolated areas in Spokane are separately sewered to provide a test situation. It is not possible under present conditions of combined sewer overflow to estimate urban runoff quality from its impact on the receiving waters since the effect of the urban runoff component is masked by the combined overflows. In the absence of local calibration data it is possible to make an estimation of water quality impact by applying the HSP simulation with literature values developed in this study. The HSP simulation of urban runoff would be particularly applicable to sizing of storage facilities for urban runoff on a statistically valid basis.

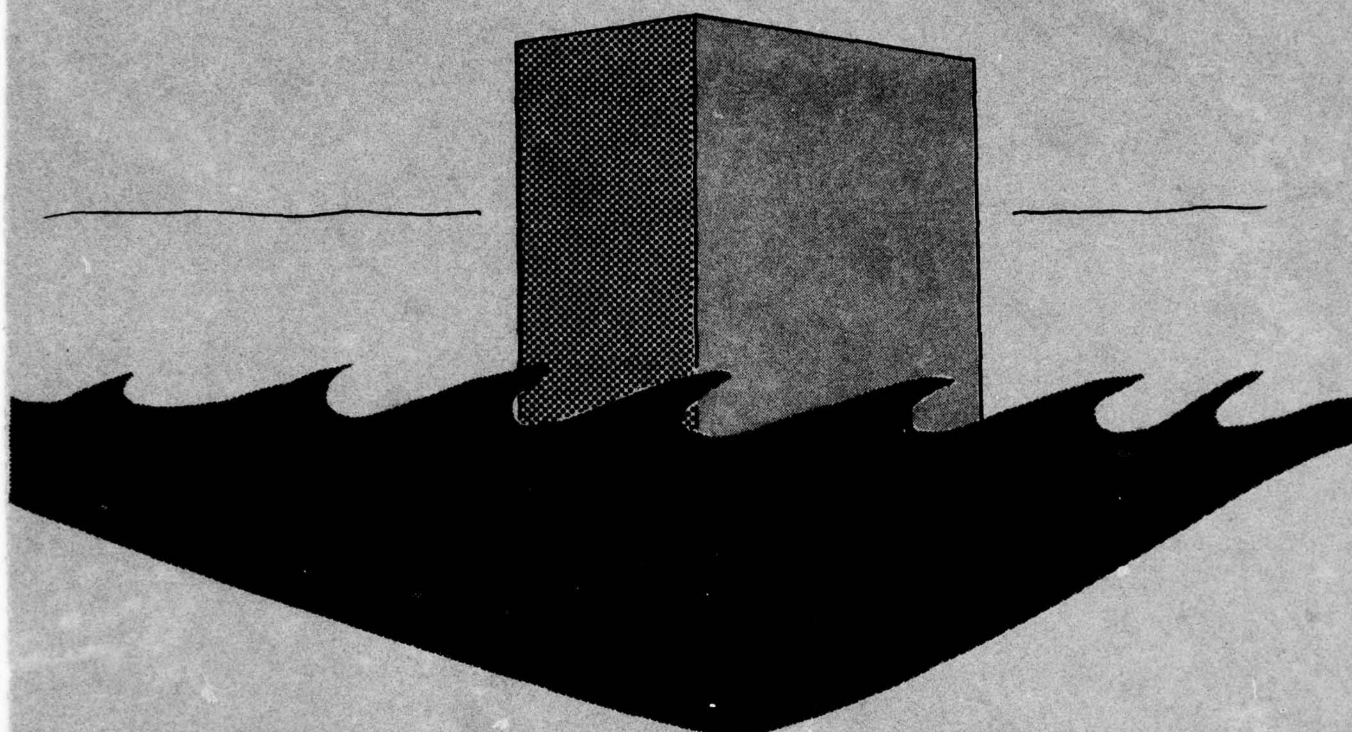
The City program of correction of combined sewer overflow problems could make good use of the simulation process to evaluate the effectiveness of alternative plans. It would not be necessary to run the entire basin simulation for most considerations. These could be handled at low cost in a variation of the urban runoff subroutine described above. Summarized results from subroutines could be used as point source inputs to the basin wide run for overall evaluation of selected plans. The HSP simulation of the runoff hydrograph would be particularly useful in the statistical evaluation of combined overflows both as to volume and pollutional impact.

Small Watershed Hydrology. Concentratión on the water quality aspects of the HSP model almost leads to overlooking its earliest use; namely, for hydrologic simulation. There are many branch streams like Rock Creek for which there are no long-term flow records. The HSP simulation could be utilized to synthesize these records. It could also be used to provide statisitical data for DOE water rights allocation as, for example, in the Little Spokane watershed.

The HSP model also provides a tool for evaluation of any proposed programs for alteration of the runoff from watersheds by either surface retention or storage.

Research. The complexities of model calibration for Long Lake illustrate that the model does not recognize many of the nuances of behavior but that it is a highly sensitive tool nonetheless. The very process of investigating the shortcomings of the simulation process are sure to lead to a better fundamental understanding of the processes in Long Lake. There is an opportunity here for a cooperative effort between local regulatory agencies and the local academic interest which have made significant contributions to the understanding of Long Lake already.

Another research application would be in connection with urban runoff. Thus far, no urban runoff sampling program has been specifically designed and implemented to gather data in the form to fit the recognized buildup-washoff algorithms such as those incorporated in HSP. With an available simulation, the data could be tested as developed.



SECTION 12

FLOOD CONTROL

12. Flood Control

Overview

Flooding from major stream flows (as opposed to local or urban runoff) has not been a major problem in the metropolitan Spokane area. The few problems that exist effect very small areas with low levels of damage and practically no threat to life. Where future problems could develop, proper zoning could prevent their occurrence.

None of the existing or potential flood control problems impact upon the suggested wastewater or sludge management plans. The existing City STP site has been determined by the City's consultants to be above flood level and the potential site area for a Spokane Valley treatment plant is not in the flood plain.

There are four urban sites which experience flooding and minor flood damage. On the Spokane River the three areas are:

1. Peaceful Valley
2. Riverpoint (industrial area east of Gonzaga U.)
3. Upriver Drive

The fourth area is:

4. From 11th Avenue south to approximate R.M. 3.5

An extensive area which regularly experiences inundation is the area adjacent to the Little Spokane River, but with negligible damage since the area is largely undeveloped at this time. There is, however, pressure for suburban expansion in the area on one hand and a significant public reaction favoring maintenance of natural conditions on the other. Refer to Figure 12-1 for the general location of the above described areas.

To put the total flood problems in perspective the following table roughly summarizes the extent of involvement at the above cited locations:

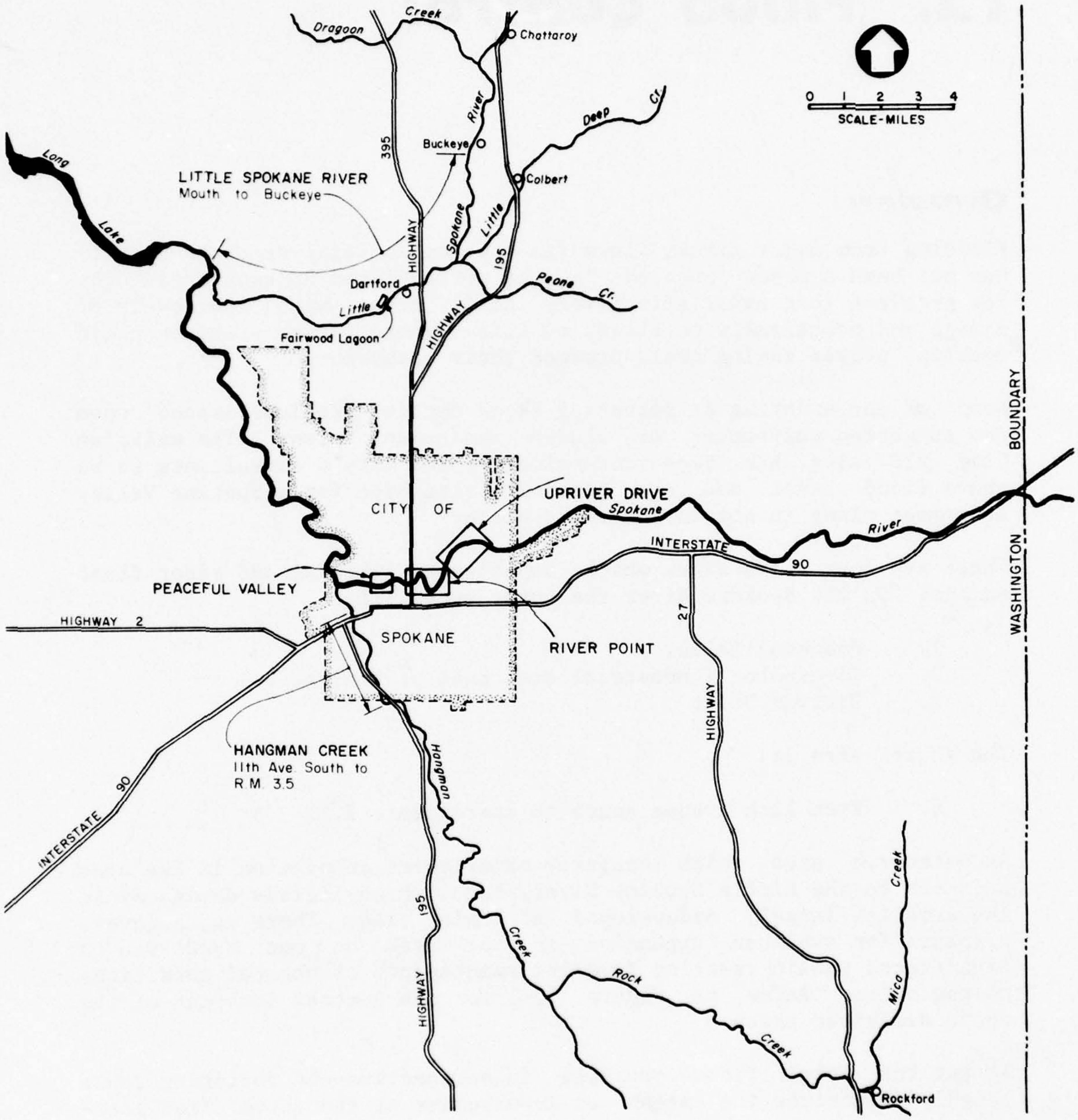


FIGURE 12-1

FLOOD PROBLEM LOCATIONS

Location	Structures Involved	Developed Area Involved Acres	Estimated Maximum Depth, Feet
Peaceful Valley	20 residences, 1 industry	11.7	4
Riverpoint	4 industrial/1 post office	8.8	3
Upriver Drive	2 apartments, 1 residence	NA	4
Hangman Creek	Up to 5 residences and farm buildings, a trailer court	NA	NA

It should be noted that Hangman Creek problems involve bank erosion and undercutting as well as inundation. The nature of the flood problems in the Spokane urban area does not call for or justify major structural responses. It is expected that small scale local improvements or non-structural approaches would be most appropriate to abatement of flood damage and flood damage potential.

Flood Plain Management Alternatives

Flood plain management alternatives are summarized schematically in Figures 12-2 and 12-3 for structural and non-structural respectively. The following alternatives to flood plain management are considered applicable to conditions in the Spokane Basin.

Major Structures. This category is subdivided into four subcategories by function: (1) for reducing flow volume, (2) for controlling the elevation of the water surface, (3) for containing the flood flow and (4) for bank protection.

Major dams and reservoir flood control alternatives are not feasible for control of Spokane flood problems due primarily to the very limited and localized nature of flooding and the existing natural flood attenuation afforded by Coeur d'Alene Lake.

Minor Structures. For localized flood containment and bank protection, candidate structural flood control alternatives are utilized and applied to possible solutions of flood problems in the Spokane area. Feasible structural alternatives considered are limited to localized levees and flood walls.

Flood Proofing. This technique includes various structural considerations that may be incorporated in the original design of a structure or added by modification to reduce flood damage. These techniques are described in detail in Sheaffer et al (1967) and U.S. Corps of Engineers (1972). The success of flood proofing measures depends substantially on accurate information of flood levels in order that structures may be designed or modified to withstand hydraulic loads which may be imposed. This technique is one of the mandatory requirements for the National Flood Insurance Program (NFIP).

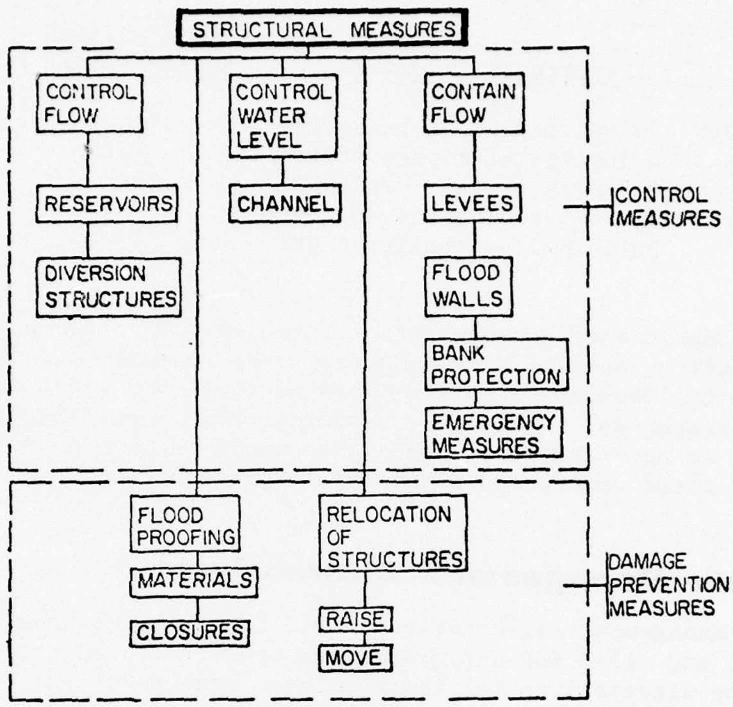


FIGURE 12-2

STRUCTURAL FLOOD PLAIN MANAGEMENT ALTERNATIVES

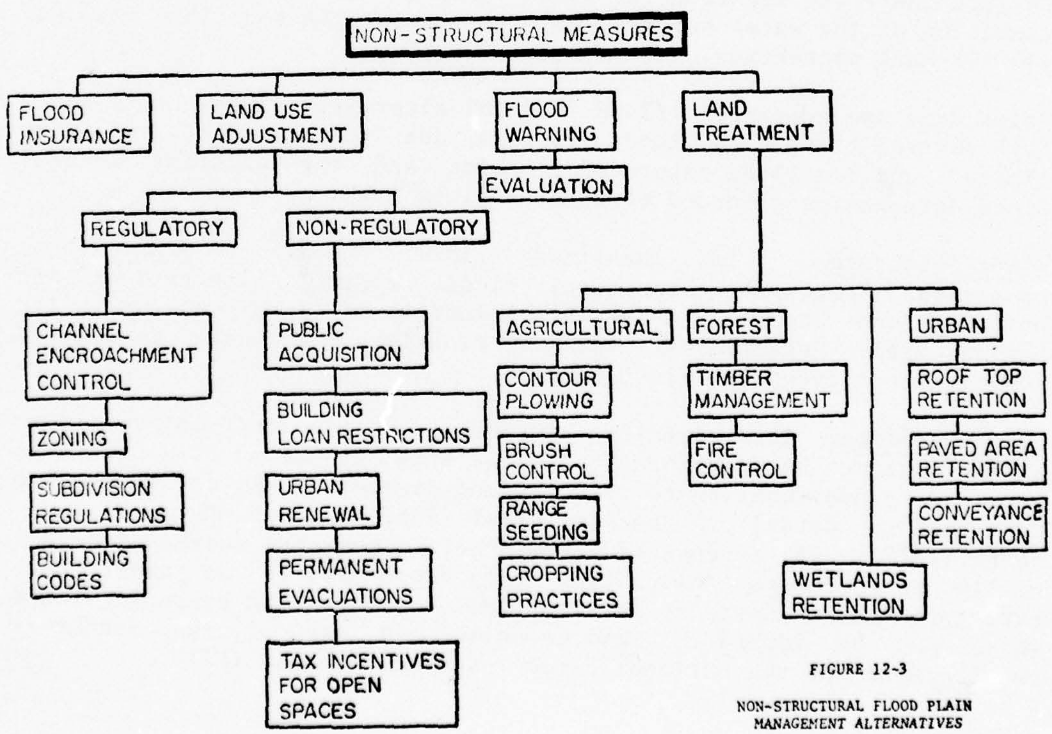


FIGURE 12-3

NON-STRUCTURAL FLOOD PLAIN MANAGEMENT ALTERNATIVES

The National Flood Insurance Program. One of the non-structural alternatives to reduction of the impact of flood damage is a flood insurance program. Such a program has been made available nationally through the NFIP under the Flood Insurance Administration (FIA) of HUD.

Both the City and County have established eligibility under NFIP and are therefore committed to establishment of acceptable flood plain management measures. Communities within the study area with identified flood hazard areas which have not established NFIP eligibility are Fairfield, Latah, Rockford, Tekoa and Waverly.

Land Acquisition. One of the alternatives to control privately-owned lands subject to flooding is the acquisition of those lands by a public agency for dedication to flood-tolerant uses such as parks and open spaces. There is also the possibility of the land being acquired by a public agency for conversion to developable land by structural means such as filling, bank protection or levees for either public use or return to the private sector for redevelopment. These considerations have general applicability to several sites in this study.

Warning and Evacuation or Emergency Protection. The Spokane area benefits from an effective early flood warning program provided by the National Weather Forecast Center (in Portland) in conjunction with the National Civil Preparedness System communications which is available to local agencies. The Washington State Emergency Services has management responsibilities for coordination of effort in responding to notification of emergency conditions. Within certain constraints, the Corps of Engineers also has authority for emergency flood protection to the extent of protecting existing and maintained levees, and other actions where there is "imminent danger" to public property.

For areas threatened by the Spokane River, advance warning based on conditions in Idaho has provided ample notice of high water conditions which has permitted emergency preparations, such as sandbagging levees.

Land treatment measures involving methods for decreasing runoff through infiltration for agricultural, forest and urban land are considered as itemized in Figure 12-3. Because of the nature of natural flow control and the extensive proportion of forest and grasslands comprising the watershed of the Spokane and Little Spokane Rivers, land treatment as a flood control measure in these watersheds is a negligible consideration. A number of alternative measures for decreasing runoff and increasing infiltration or retention are shown in Figure 12-3 under three general kinds of land use: agricultural, forest and urban. For this study, the amount of runoff from urban land to major streamflow is negligible. For the watershed of the Spokane River in Idaho, the portion in agricultural lands is also negligible, leaving forest lands as the primary concern. Both forest and agricultural lands are tributary to the Little Spokane and Hangman Creek watersheds.

The watershed with greatest need for increased infiltration or retention is Hangman Creek. This stream is subject to extreme peak flow due to the combination of slope, soil type and agricultural practices. Far more critical to the area than flood control is the extreme need for reduction in erosion of the valuable Palouse soils. There is need for improvements in retention in connection with agricultural practices.

Application of Alternatives to Specific Problems. The foregoing alternatives are considered for their applicability and appropriateness to solution of the specific problems in the study as discussed in the remainder of this section. Figure 12-4 provides a checklist of alternatives considered and their applicability to each specific site.

The mandatory actions to be taken under NFIP are key actions and are all or part of the suggested plan of action in many cases. These mandatory actions are assumed to be taking place in any case so that the focus in this study is on additional actions not required under NFIP. Therefore, in Figure 12-4, Flood Insurance, Flood Proofing and flood plain management through Regulatory Control are assumed to be given in all cases.

	Spokane River					
Alternatives	Pleasant Valley	Riverpoint	Upriver Drive	Little Spokane	Hangman Creek	Rock Creek (Rockford)
Structural						
Dams	NFE	NFE	NFE	NFE	NFE	NFE
Channel Improvement	NFE	NFE	NFE	NFE	NFE	NFE
Levees and Walls	NCE,2	NFE	NCE,2	UNP	NCE	NCE
Bank Protection	NA	NA	NA	NA	NCE,NA	NA
Flood Proofing	MR,1	MR,1	MR,1	MR,1	MR,1	MR,1
Relocation of Structures	NCE	NCE	1	NCE	2	NCE
Non-Structural						
Flood Insurance	MR,2	MR,2	MR,2	MR,2	MR,2	MR,2
Land Use Control	MR,2	MR,1	MR,1	MR,1	MR,1	MR,1
Public Acquisition	2	2	NS	NS	NS	NS
Warning and Emergency Measures	2	2	2	NA	2	2
Land Treatment	NFE	NFE	NFE	NFE	NFE	NFE
No Action	2	2	2	2	2	
Other		1*				

1 = Primary suggestion NA = Not applicable
2 = Secondary suggestion NFE = Not Functionally Effective
NS = Not suggested NCE = Not Cost-Effective
UNP = Unacceptable to Public MR = Mandatory Regulation per NFIP
* = Fill to protect post office access and to raise Springfield Avenue

FIGURE 12-4

FLOOD CONTROL ALTERNATIVE MATRIX

Spokane River Unmet Needs

General. Statistical analysis of streamflow records shows that the magnitude of the 100-year flood on the Spokane River at Spokane is 52,000 cfs. There have been several historical floods of record that have approached this magnitude, the most recent being the flow of January 1974 which was 46,100 cfs. The largest flood for which water surface data are available is the flood of December 1933 which was 47,800 cfs. The water surface data from these large floods of record, which so closely approach the 100-year flood, are the basis for development of the 100-year flood profile developed in this study and used to define the flood areas. The accuracy of the flood area definition is limited by the topographic mapping which is 1-inch equal 400 feet horizontal and a contour interval of 10 feet. The Spokane River is well contained in its channels, with substantial freeboard, even at the 100-year flood, throughout the study area except at three locations: R.M. 73.6 at Peaceful Valley, R.M. 75.5 to 76.2 designated Riverpoint (east of Gonzaga University) and R.M. 76.8 to 78.0 along Upriver Drive.

River Mile 73.6, Peaceful Valley. The total area potentially affected is approximately 11.7 acres containing 20 single family residences and one industrial structure. Refer to Figure 12-5. The estimated potential damage with the 100-year flood and failure of temporary sandbag

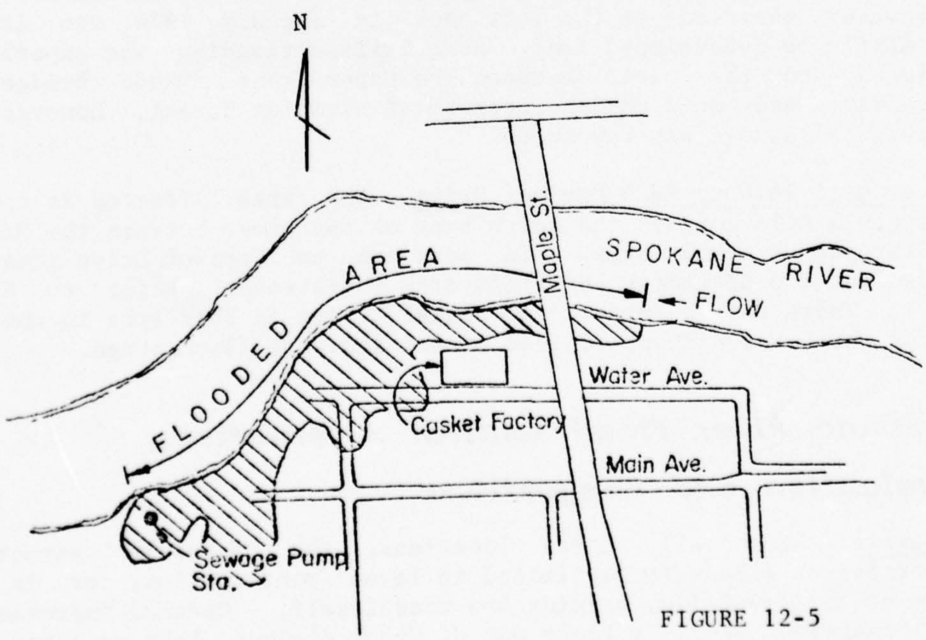


FIGURE 12-5

PEACEFUL VALLEY FLOOD AREA

dikes is street, yard and basement flooding involving the 20 homes, with first floor damage to some. The single industrial facility in the area is a casket factory whose concrete floor is above the flood plain, the flood potential being primarily to the storage yard. The residences in the area are single family wood structures, most over 40 years old. The 1974 flood, which was within 0.6 feet of the 100-year flood, caused limited damage as a result of basement and street flooding. No estimate of damage was reported.

River Mile 75.5 to 76.2 Riverpoint (near Gonzaga University). The total area affected is approximately 24.2 acres of which 8.8 acres contain development, all industrial. Refer to Figure 12-6. The developed area affected is on Columbus Street between Trent and Springfield, on Springfield from Cincinnati to the river, Superior Street on both sides of Sprinfield, the west side of the Post Office and the riverside of buildings at the foot of Cincinnati and Columbus. Maximum depth of flooding is estimated to be 3 feet which would severely restrict access to the Post Office and many of the industries located in this area, most of which would be able to sustain a flood with little damage other than disruption of operation caused by limited access. Many floor levels are at truck loading dock level. The length of riverbank involved is approximately 1800 feet adjacent to the developed industrial area. The 1974 flood, which was within 1.5 feet of the 100-year flood level, caused no reported structural damage other than street flooding which limited access to the area.

There is also a limited overbank condition at floodflows on the south side of the river (left bank) opposite the above described. The highwater observed on the left bank in January 1974 was limited primarily to undeveloped land. Some limited flooding was experienced adjacent to the river between the Upper Trent Avenue Bridge and Broadway, and at a marina upstream of Division Street, however, no structural damage was reported.

River mile 76.8 to 78.0 Upriver Drive. The area affected is approximately 1-mile long on the north bank of the river between the Mission and Greene Street Bridges. In addition to Upriver Drive itself, a house and two apartment buildings are threatened. Refer to Figure 12-7. There was no actual structural damage in this area in the 1974 flood which was within 1.5 feet of the 100-year flood stage.

Spokane River Flood Control Alternatives, Evaluation and Suggestions

General. For all three locations, the feasible structural alternatives appear to be limited to levee construction, or in the case of Upriver Drive, raising the road itself. Channel improvements and management of river flows out of Coeur d'Alene Lake as a means of flood reduction for the Spokane River have been investigated in depth

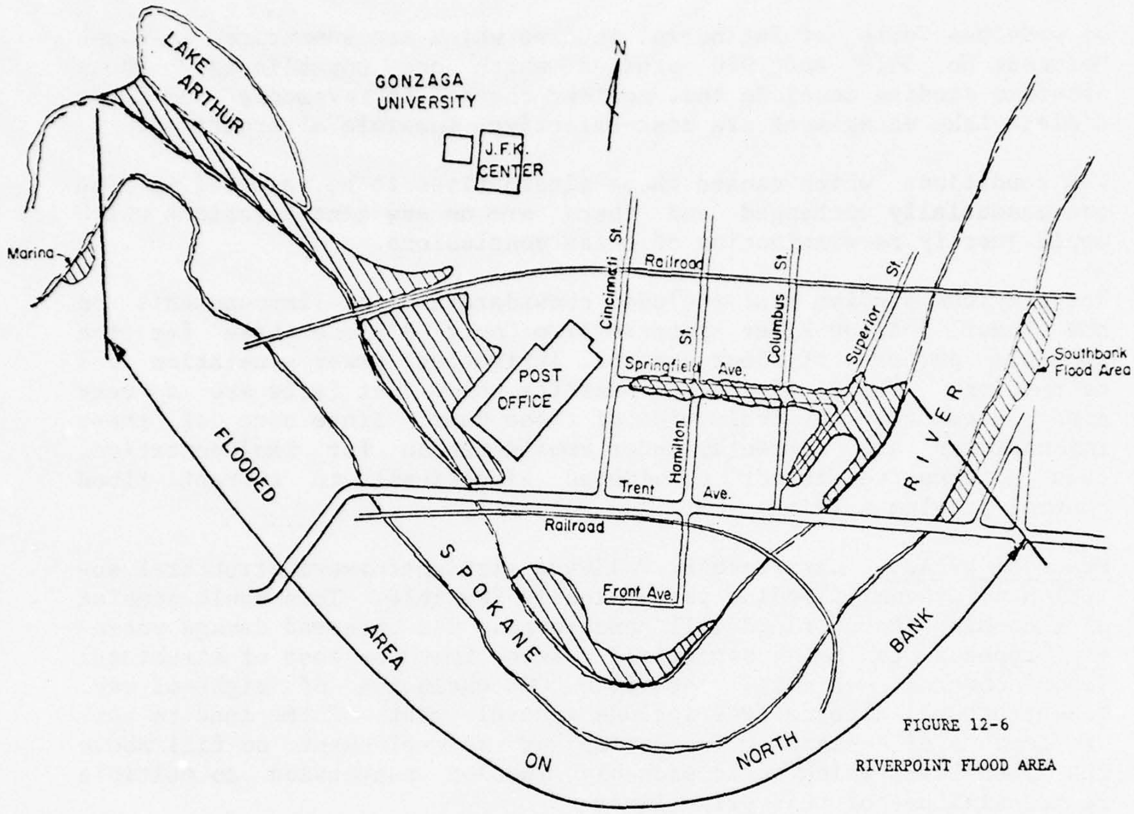


FIGURE 12-6

RIVERPOINT FLOOD AREA

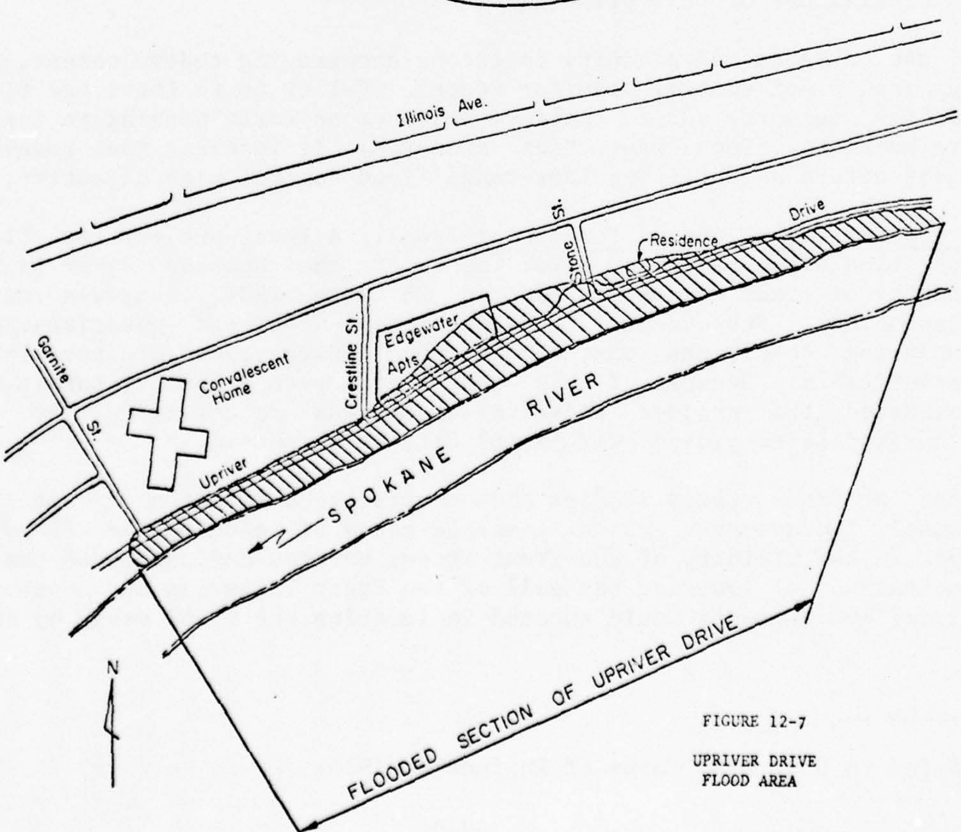


FIGURE 12-7

UPRIVER DRIVE
FLOOD AREA

by previous Corps of Engineers' studies which are summarized in House Document No. 531[1/] and 1970 studies which are unpublished. These previous studies conclude that neither channel improvements nor Coeur d'Alene Lake management are cost-effective, feasible alternatives.

The conditions which caused these alternatives to be rejected in 1950 are essentially unchanged and there are no new considerations which would justify re-examination of these conclusions.

The previous studies also included consideration of impoundments on the Coeur d'Alene River upstream from Coeur d'Alene Lake for the multiple purposes of flood control, irrigation, power generation and recreation. The flood control benefits below Post Falls are a very minor element in the evaluation of these dams. Since none of these impoundments are currently under consideration for implementation, this alternative is not considered significant to current flood control problem solving.

Peaceful Valley. At Peaceful Valley a straightforward structural solution to prevent flooding is physically feasible. This would consist of a combination of flood wall and levee. The observed damage potential appears to be substantially less than the cost of structural flood control estimated at $150,000 exclusive of right-of-way. Non-structural alternatives include redevelopment of the land to park use capable of sustaining inundation or redevelopment on fill above the flood level which would probably involve conversion to multiple residential use of this prime land.

In the absence of planning decisions encouraging redevelopment, the suggested flood control plan for Peaceful Valley is to institute flood proofing measures and to continue reliance on early warning to institute emergency flood protection measures. It is clear that redevelopment offers an excellent long-range flood control plan objective.

Riverpoint (Trent Avenue Industrial Area). A levee project for flood protection along the right river bank of the Spokane River in the vicinity of Trent Avenue was adopted 28 June 1938, but was never constructed. Subsequent investigations disclosed unsatisfactory foundation conditions that make the construction of the levee impracticable. Because of this and the fact that local interest had considered the project undesirable, it was recommended that the authorized levee project within the City be abandoned.

These previous Corps studies also covered consideration of specific channel improvements as a possible means of reducing the flooding depth in the vicinity of the Trent Street bridges and concluded that a combination of lowering the sill of the Upper Falls Dam and upstream channel improvements would succeed in lowering the flood stage by only

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[1/] Refer to U.S. Army Corps of Engineers (1950).

9 inches at the Trent Street bridges. Channel improvements were not suggested because of the high costs and small benefits.

The rejection of levee and channel improvements as possible alternatives by the previous studies would appear to preclude any solution to the flooding problem other than to vacate the affected areas and their designation as flood plain or to redevelop the area with fill above the flood plain.

Suggested actions are as follows, considering the riverfront by sections from west to east.

1. No action is suggested for the section between Lake Arthur and the river east to the railroad embankment on Broadway extended since there is no development subject to damage. If an element of the linear waterfront park is developed here, the road between Lake Arthur and the river could be built above flood level but with culverts to allow flooding through so that the road would not have to function as a structural levee.

2. In the section from the railroad embankment to the West Trent Bridge, it is suggested that some filling be done on the southwest and northwest side of the Post Office to protect continuous access to this important facility. Again, there is no justification from a damage abatement viewpoint. A more permanent solution can await riverfront development for open space. In the meantime, development in the large area northwest of the Post Office should not be permitted without prior solution of the flooding problem.

3. In the section from the West Trent Bridge to the East Trent Bridge it is suggested that no action be taken other than to prohibit development in the railroad operating property subject to flooding.

4. In the section from the East Trent Bridge to the railroad at Broadway extended it is suggested that development in vacant parcel 17534-0216 be prohibited and that any additional development in parcel 17534-0215 be prohibited. The flooding of Springfield Avenue by waters entering the east end of the street between parcels 0215 and 0216 should be investigated for possible improvement west of Columbus Street by raising the street grade to provide a dry approach to the Post Office. Consideration should be given by the City to acquisition of the presently vacant parcel 17534-0216 with later acquisition of the lot occupied by Dorsey Brothers on the east side of Superior Street. With the full width of the lots to work on, it may be possible to construct a broad fill which would serve as a levee on the unsatisfactory foundation material.

Upriver Drive. The only structural alternative for flood control involving existing buildings subject to flood damage, other than raising Upriver Drive, would be to provide flood proofing by permanent structural walls around the few threatened buildings. Removable sections would be required to provide for driveways and other access. Raising and/or moving the individual house which is in greatest danger onto a new foundation appears feasible and practical.

The primary suggestion for the Upriver Drive area east of the Washington Water Power Building is the prevention of further development on sites subject to flooding pending solution of the flooding problem. This will be taken care of by the mandatory requirements of NFIP.

Reconstruction of Upriver Drive at a grade above flood plain connot be suggested on a cost-benefit basis. It is suggested that the City make a policy decision as to whether they plan to modify the grade of Upriver Drive for any reason, such as upgrading to parkway status. If this is not imminent, the individual home owner should be encouraged to raise and/or move back his home and the apartment owners to proceed with flood proofing. Land use and/or building restrictions should be instituted to prevent further development within the flood plain.

Little Spokane River Unmet Needs

The 100-year flood flow on the Little Spokane River is calculated from statistical analysis to be 4700 cfs. This is a low peak flow for a tributary area of 665 square miles with no artifical controls. Hangman Creek, with almost the same tributary area, has a 100-year flood flow of 28,000 cfs. The largest flood on the Little Spokane within the relatively short period of record is that of February 1970 at 3170 cfs. Overbank conditions occur at flows substantially below the 100-year flood flow, as for example, at a flow of 1680 cfs observed in December 1973.

The river gradient is relatively flat in its lower reaches, below Chattaroy at approximate R.M. 22, and has developed a characteristic meandering configuration with a small channel. At higher flows, the river goes overbank throughout a large part of this lower reach, as it has always done at frequent intervals, essentially on an annual basis. Flows outside the low flow channel are the result of well attenuated peaks with an absence of extreme peaks. Man's impact on the river channel has not significantly hindered flow (except in the last mile due to backwater from Long Lake). With the exception of several residences in the Dartford area and in the vicinity of Buckeye, there is little structural flood hazard due to high flow conditions of the Little Spokane River. Access to the sewage treatment lagoons at Fairwood is restricted during high flow, but it is expected that this interim facility will be abandoned with the construction of the permanent North Spokane Sewage System.

Little Spokane River Alternatives and Evaluation

Structural flood control measures cannot seriously be considered on the Little Spokane River. Reservoir impoundments, even if sites were available, would not modify naturally attenuated peaks significantly. Levees and channel straightening would be costly, unaesthetic and would change the character of the area, a result clearly not desired by the local residents and owners of involved property based on recent investigations by DOE. Structural measures are not suggested. It is suggested that flood control of the Little Spokane River, or more correctly, the recognition of the normal high flow river channel, consists of education and control against encroachment of the high flow channel by incompatible development which cannot withstand inundation. Existing "flood prone" structures should be relocated or flood proofed.

Hangman Creek Unmet Needs

Statistical analysis of Hangman Creek flows establishes a 100-year peak of 28,000 cfs. This peak flow is of the same order of magnitude as the typical spring flood flow on the Spokane River itself with almost ten times the tributary area. The January 1974 flood at 18,300 cfs is the second highest peak observed in the period of record, the highest being 20,600 cfs in 1963.

In contrast to the Little Spokane River which has low peak flows and the Spokane River for which there is ample warning time for high flows, Hangman Creek has extremely high peak flows that can be generated with little advance warning. Most of Hangman Creek is through rural area where there are few improvements which encroach on potentially flooded areas. Flood problems experienced in 1974 are typical of flood damage exposure on Hangman Creek through the urban area. Problems in 1974 extended from the vicinity of the 11th Avenue Bridge upstream to a point approximately 1500 feet south of Highway 195 and consisted of locally severe bank erosion, limited inundation of individual residences and failure of poorly constructed levees subjected to high stream velocities. In addition, the Hangman Valley Golf Course which was constructed with full knowledge of flood exposure suffered extensive damage in 1974 from silt deposition on fairways and destruction of two pedestrian bridges. There are no comprehensive flood damage evaluations for Hangman Creek.

Hangman Creek Alternatives and Evaluation

Hangman Creek at 100-year flood stage can be expected to be a wild and destructive force within or near its normal flood channel, typified by extremely high velocities and heavy silt load. Severe erosion and bank cutting within the flood zone would be structurally very difficult to control.

Alternatives involving upstream impoundment, which were previously studied by the Corps of Engineers, concluded that flood control reservoir projects were not feasible, due in part to the very limited amount of the total watershed which would be controlled by any one structure.

Upstream alternatives for land management to prevent high runoff and erosion are related to farming practices on the Palouse soils which cover a large proportion of the Hangman Creek watershed. Adoption of suggested farming practices are not expected to substantially affect peak flows which are often associated with frozen ground conditions. The primary goal of these management techniques is reduction of erosion and consequent reduction in silt load. These measures are expected to be pursued by the U.S. Soil Conservation Service independent of flood control concerns.

Flood peak reduction of the extremely "flashy" flow of Hangman Creek by either construction of impoundments or watershed management is judged to be infeasible in connection with alleviation of the minor flood damage problems addressed in the downstream areas. Watershed management for erosion control would have some long-term minor flow reduction benefits, but insufficient to significantly impact most flooding problems. The relatively low flood damage potential, limited number of residential structures and the fact that damage is limited to private property substantially eliminates the justification for publicly funded flood control projects on Hangman Creek.

The only feasible damage reduction technique open to most of these individuals is to remove the existing structures from the threatened areas. In some cases, raising the floor level by a new foundation may be satisfactory where inundation is the only threat. Most single family residences cannot be flood proofed except by raising the floor level. Where the threat is from erosion, moving back from the threatened land is the only alternative.

Where bridge abutments, roads and other non-residential improvements providing public service are threatened by erosion, bank protection is ultimately required either in anticipation of critical flows or on an emergency basis. At present, reliance is being placed on an emergency response. The very flashy flow condition of Hangman Creek and high flow and velocity potential make long-term permanent bank protection to meet the most critical condition very costly.

In general, channel improvement is infeasible at most locations since the stream is relatively straight, the channel occupies all available space and velocities are already high.

Non-structural flood control measures must be relied on to control and limit the possible increase of flood damage exposure on Hangman Creek. Relatively few residences are involved in Hangman Creek flooding problems since the threatened areas are presently at low density in

semi-rural development. Since the NFIP will require regulatory land use control, the damage exposure will be prevented from increasing. It is suggested that the areas threatened by flood damage be defined to include not only those areas subject to inundation but also those areas that are threatened by erosion.

Rock Creek Unmet Needs and Evaluation

The flooding problem of Rock Creek at Rockford has been studied periodically since 1933. The potential flood plain for the 100-year flood flow is approximately 18 acres, all on the east side of the stream. The area is occupied by much of the community's commercial and public structures.

A levee approximately 1700 feet long from the Emma Street Bridge south was constructed following the 1933 flood and improved by the Corps of Engineers in 1965. A study was made in 1970 by the Corps to evaluate the needs for improvement of the levee and to make a cost-benefit comparison. The need determined was to raise 700 feet of levee by 3 feet and to rebuild the remaining 1000 feet. The cost-benefit ratio was determined to be 0.9. No action has been taken to implement the plan.

Re-evaluation of the 100-year flood profile in this current study confirms that the levee is marginal in height and probably inadequate considering the backwater potential of the Emma Street Bridge. An earth dike of questionable security was constructed in 1974 to prevent flood waters from backing into the area from between the Emma Street Bridge and the railroad embankment to the north.

The unmet need for flood control remains as defined by the 1970 Corps of Engineers' study plus the need for reconstruction of the emergency dike between the bridge and the railroad.

It is suggested that non-structural flood control measures to prohibit further development within the flood plain be instituted and that flood proofing of existing structures be encouraged in accordance with NFIP requirements.

Institutional and Financial Considerations

The institutional need relative to flood control in the Spokane area fall into three categories: (1) those related to making planning decisions, (2) those related to enforcing non-structural alternatives such as zoning and (3) those related to providing financing for acquisition or structural alternatives.

Both the City and County have all the required powers to fulfill all three needs and further are the only agencies empowered to fulfill the

first two needs. The only area in which institutional alternatives require consideration is in support of financing. The alternative institutions which can function in this area are as follows:

1. Diking District

2. Drainage District

3. Diking, Drainage and Sewerage Improvement District

4. Flood Control District

5. Flood Control Zone District (FCZD)

Institutions 1, 2 and 3 above can provide funding only through special district assessments. The City and County can also provide this kind of funding through formation of LID's and therefore, these three institutions which were provided by early legislation are essentially obsolete. Flood Control Districts can, in addition to special assessments, provide funding through general obligation bonds. A FCZD has the same financing powers as the County, including service charges, and some planning and regulatory powers.

The primary reason for consideration of an FCZD is to provide coordination of a flood control effort extending through several county and municipal jurisdictions. The particular flood control problems and their feasible solutions in the Spokane area are limited in extent and occur within City or County jurisdiction. Therefore, there is no advantage to consideration of a FCZD.

SECTION 13

URBAN RUNOFF MANAGEMENT

13. Urban Runoff Management

Introduction

The urban drainage problem for the study area is unique in several respects. In general, the present and forecast areas of urban development do not have a natural surface stream drainage pattern. Almost the entire urban area of development is on highly permeable soils where a surface stream system never existed in nature. The one fairly extensive area that is an exception to this description is that part of the City south of the Spokane River where pre-existing streams, swamps and springs have lost their natural identity by being incorporated into the City sewer system.

In nature, before the creation of impervious areas by urban development, most of the precipitation falling on the present and forecast urban areas never reached a surface stream but rather percolated into the soil where the ultimate pathway was split between evapotranspiration and recharge of groundwaters. Hence, there are and were no natural surface streams of even an ephemeral nature to provide a baseline of natural runoff quantity or quality.

Within the City, runoff from manmade impervious areas is now discharged into the Spokane River through a system of sewers, mostly of the combined type in which sanitary sewage flows in the same pipe, but some in separate storm sewers. The combined sewer problem is the subject of an extensive ongoing study program by the City. The goal of the program is to minimize the pollution caused by overflow of untreated sanitary sewage not inextricably mixed with storm waters rather than to address the problem of the storm waters themselves.

The North Spokane suburban area contains a limited storm drainage system that includes both sewers and roadside ditches. The ultimate point of discharge is the Little Spokane River. There are no combined sewers in the North Spokane suburban area. The area in general slopes directly toward the Little Spokane River.

The Spokane Valley suburban area contains practically no storm drainage systems. All drainage is essentially by percolation, either from "dry wells" dug for this purpose or by simple infiltration into the ground surface. The ground surface slopes to the Spokane River so that the Spokane River would be the recipient of any collected storm drainage. The drainage configuration in general consists of swales parallel to the river and separated from the river by low ridges so that any collection system would require an extensive trunk system.

Urban Runoff Plan Development

Urban runoff (URO) concerns are segregated into the basic categories of pollution abatement and flow control for which both structural and non-structural management procedures will be defined.

The primary unmet need to be addressed in URO management planning for the metropolitan area is the serious consequences of overflow bypass of combined sewers during storm overflow conditions. To this end the City has already initiated a planning program, the objective of which will be control of this problem. The City has submitted to DOE a Plan of Study dated September 1974 for "Facilities Planning for the City of Spokane Sewer Upgrading and Overflow Corrections." The plan of action adopted by the City provides that Spokane will proceed with detailed planning of the proposed URO management systems and will implement that plan in a cost-effective manner by the design and construction of facilities which will solve the combined sewer overflow problem. The City will select and implement remedial measures which will either eliminate the discharge of sanitary wastes mixed with storm water or will provide treatment for the mixed sanitary and storm waters to minimize the impact of the sanitary component on the receiving waters. The City Plan of Study is not intended to address treatment of separate URO.

URO would be treated only as incidental to treatment of sanitary wastes in combined flows. As of this date, EPA has not established criteria for any level of treatment for separated URO and the City is not under directive to abate pollution due to separate URO. Refer to NPDES Waste Discharge Permit No. WA-002447-3 for the City treatment plant.

<u>Alternatives Considered by the City Plan of Study</u>. The four alternative methods for correction of the combined sewer overflows specifically enumerated in the City Plan of Study will have the following impacts on waste treatment plant utilization and on quantity of pollutants reaching the river.

<u>Alternative 1</u> will consider storm relief sewers with satellite treatment facilities at various overflow points to the Spokane River. This alternative does not require storm water capacity in the waste treatment plant.

<u>Alternative 2</u> will consider storm relief sewers with storage facilities so that all potential overflows can be stored for delayed conveyance to the STP without requiring any capacity increase in the existing interceptor sewers or the new STP. This alternative has the minimum impact for URO pollutant load to the river since all flows including the URO component would experience full treatment at the STP.

Alternative 3 will consider storm relief sewers combined with new relief interceptor sewers to the waste treatment plant together with further enlargement of the new STP to treat all combined flows. The impact on pollutant load to the river would be the residual waste load following combined flow primary treatment by excess flow clarifiers.

Alternative 4. The complete storm and sanitary sewer separation with direct discharge of storm waters to the Spokane River alternative makes no demand on the available capacity in the City STP. The impact on pollution load to the river is that associated with discharge of untreated separate URO.

Elements of all alternatives may be considered for application throughout the system. Alternatives 2 and 3 would provide not less than primary and a significant proportion of secondary treatment for combined flows. The level of treatment selected for combined flows in Alternative 1 would certainly be no less than would limit pollution to the equivalent of discharging the storm flow separately and Alternative 4 does in fact discharge the storm flow separately and untreated. The most severe impact on receiving water quality would therefore be the assumption of discharge of separate untreated storm flows. The consequences of this most severe condition should be known. This study is directed toward forecasting the separate storm water pollution load and evaluating its impact.

Development of Urban Runoff Wastewater Quality Impact

Inasmuch as EPA has not established standards for URO quality, it is necessary to assume probable standards for the purpose of evaluating the water quality impact of URO.

The URO pollution load is known to be highly variable in intensity, frequency and duration of occurrence due to the interaction of the corresponding characteristics of rainfall and the pollutant accumulation and washoff process. Therefore, it is anticipated that URO criteria will recognize this variability in being stated in statistical terms except where cumulative effects are of prime concern, such as discharge of nutrients to a lake.

The following have been developed by this study as criteria for allowable water quality impact due to URO.

1. Biochemical Oxygen Demand (BOD). For the specific conditions of the receiving waters in this study, a depression of 1 mg/l of DO or more at 24 hours is selected as indicative of the possible need for abatement measures. For typical summer temperature and flow conditions in the Spokane River such a critical level would be associated with a BOD of the combined river and URO flows in excess of 5 mg/l.

2. <u>Bacterial Pollution</u>. The total coliform requirements for Class A waters provide that the median count not exceed 240/100 ml and that less than 20 percent of the samples not exceed 1000/100 ml, when associated with a fecal source. Completely separated storm drainage is here interpreted to be a fecal source, although it would presumably be from other animal sources than man.

The foregoing regulation for Class A waters indicates that coliform levels higher than 1000 org/100 ml might be tolerated for very short times. To obtain a quantifiable basis for evaluation of the possible need for abatement of coliform pollution from URO, the following conditions and criteria are selected based on untreated URO being assumed to have a mean coliform concentration of 100,000/100 ml:

a. The receiving water total coliform concentration from URO sources not to exceed 1000 mg/100 ml when the URO from a 2-year 24-hour storm is tested against the mean summer flow for the lowest summer month, 908 cfs.

b. The receiving water total coliform concentration from URO sources not to exceed 10,000 org/100 ml when the URO from a typical rainfall event is tested against the 10-year 7-day low flow, 860 cfs.

3. <u>Nutrients</u>. The assumed allowable phosphorus and nitrogen levels for URO is based on a reasonable level in comparison with natural background levels and loads from treated sanitary sewage effluents based on cumulative annual and summer season loadings. For evaluation of ammonia toxicity impact, the short-term impact is critical. Limiting N level for ammonia toxicity is selected at 0.4 mg/l for a 2-year storm event of 24-hours duration.

4. <u>Toxicants</u>. There is a lack of data on specific levels of toxic substances in URO, except for lead, which is believed to have its source in automobile fuels and is therefore of widespread occurrence. Lead is selected as an index to possible need for toxic material abatement.

Evaluation of toxic substances impact is based on the following derived standards:

a. A receiving water lead concentration of <u>0.05 mg/l</u> (the USPHS Standard) at mean streamflow level with a URO pollutant load associated with a 2-year 24-hour storm event.

b. A receiving water lead concentration of <u>0.10 mg/l</u> resulting from a typical summer rainfall event at stream 10-year 7-day low flow condition.

Forecast Urban Runoff Flow Quantities

Forecast URO flows associated with year 2020 development conditions has been derived for each of the three basic planning areas for annual and summer season conditions using a 24-hour storm event of 2-year return frequency. The basis for development of URO flow quantities is summarized in Table 13-1. Urban flow quantities derived from Table 13-1 criteria are summarized in Table 13-4.

TABLE 13-1

BASIS FOR URBAN RUNOFF FORECASTS

	Forecast by Years			
	1980	1990	2000	2020
Forecast Sewered Population				
City	177,945	182,506	189,282	204,315
North Spokane	17,220	38,561	44,627	62,482
Spokane Valley	52,227	63,166	74,061	91,021
Forecast Impervious Area, Acres				
City, max[1]	8,008	8,213	8,518	9,194
min[1]	5,694	5,840	6,057	6,538
North Spokane, max[2]	620	1,388	1,607	2,249
min[2]	396	887	1,026	1,437
Spokane Valley, max[3]	2,141	2,590	3,037	3,732
min[3]	1,462	1,769	2,074	2,549
Forecast Annual Runoff, Ac.Ft.				
City, max[4]	8,504	8,722	9,046	9,764
min[4]	6,047	6,202	6,433	6,943
North Spokane, max[5]	698	1,563	1,809	2,532
min[5]	446	999	1,155	1,618
Spokane Valley, max[6]	2,436	2,947	3,456	4,247
min[6]	1,664	2,013	2,360	2,901

[1] Range 0.045 Ac/cap. to 0.032 Ac/cap.
[2] Range 0.036 Ac/cap. to 0.023 Ac/cap.
[3] Range 0.041 Ac/cap. to 0.028 Ac/cap.
[4] At mean rainfall 18.2 in/yr and 0.7 coef. (1.062 Ac.ft/Ac.yr)
[5] At mean rainfall 19.3 in/yr and 0.7 coef. (1.126 Ac.ft/Ac.yr)
[6] At mean rainfall 19.5 in/yr and 0.7 coef. (1.138 Ac.ft/Ac.yr)

Urban Runoff Pollutant Load Forecast

In order to make an evaluation of potential pollutant washoff more specific to Spokane precipitation and soil permeability, a calculation is made of the pollution yield based on the Lombardo and Franz[1/] equations and loading factors developed from the literature. The results are shown in Table 13-2 for a unit of impermeable area.

TABLE 13-2

CALCULATED SEASONAL POLLUTANT YIELD
FOR UNIT IMPERVIOUS AREA
SPOKANE RAINFALL PATTERN

Pollutant	Season	Pollutant Yield, Pounds per Impervious Acre	
BOD	Winter	8.2	
	Spring	13.6	
	Summer	8.8	
	Fall	14.3	
	Annual	44.9	
		Kjeldahl N	Total N
Nitrogen	Winter	1.26	1.68
	Spring	1.36	1.81
	Summer	.88	1.17
	Fall	1.30	1.73
	Annual	4.80	6.39
		Ortho P	Total P
Phosphorus	Winter	.56	2.43
	Spring	.62	2.70
	Summer	.40	1.74
	Fall	.59	2.57
	Annual	2.17	9.44

1/ Lombardo, P.S. and Franz, D. 1972. Mathematical Model of Water Quality Indices in Rivers and Impoundments. Hydrocomp Inc.

The resultant yields expressed as mean concentrations in the calculated Spokane runoff are shown below:

Parameters	Mean Concentration mg/l
BOD	15
Kjeldahl N	1.6
Ortho P	0.7

These results are in agreement with the range of values for BOD and Kjeldahl N measured for the Seattle area. The values measured at Seattle for Ortho P are substantially lower than the calculated Spokane values but are within the same order of magnitude. A comparison with the Seattle area observations is shown below:

Parameter	Seattle Area Measurements for 6 acres, 32 events High	Low	Mean	Spokane Calculated Values
BOD mg/l	75	1	18.4	15
Kjel. N mg/l	7.6	.46	2.29	1.6
Ortho P mg/l	.31	.01	0.10	0.7

The selected range of unit yields for evaluation purposes based on the above are summarized in Table 13-3.

TABLE 13-3

SELECTED RANGE OF POLLUTANT YIELDS FROM URBAN RUNOFF FOR SPOKANE VICINITY EVALUATION

	Range of Pollutant Yield, Pounds Per Impervious Acre					
	Annual		Summer Season[1/]		Typical Summer Event	
Parameter	High	Low	High	Low	High	Low
BOD	90.0	45.00	27.0	13.50	2.25	1.26
Total N	12.8	6.40	3.4	1.70	.34	.17
Total P	9.4	2.35	2.6	.65	.77	.19

1/ June 1 through September 30.

The selected criteria in Table 13-3 are combined with forecast impervious areas for the year 2020 in Table 13-4 to develop ranges of forecast pollutant loads from the three service areas for annual, summer season, 24-hour 2-year return and average typical events. One basis for evaluation of the impact of URO pollution loads is a direct comparison with the corresponding sanitary pollution load from the same area. These data are also provided in Table 13-4 for the forecast treated sanitary effluent assuming 1983 effluent standards for activated sludge secondary treatment plus seasonal phosphorus removal.

Evaluation of Urban Runoff Water Quality Impact

In order to evaluate the impact of URO on the water quality of impacted receiving waters, it is necessary to define the background water quality of the receiving water. (Table 13-10 summarizes background water quality levels.)

City Service Area. Refer to Table 13-5. On a long-term basis the Spokane River provides large dilutions to the City URO flows. Only for intense short-term events is the dilution of the order of 10 to 1 or less.

With large dilutions over the long term, the long-term increment in pollutant parameter concentrations from URO sources are small in an absolute sense, in comparison with natural background and in comparison with treated sanitary effluent from the same area. The potential summer season phosphorus enrichment from City URO is 10,625 pounds compared with 41,000 pounds in sanitary effluent treated for P removal.

The short-term potential impact of BOD on DO is below the estimated abatement need level for 24-hour 2-year return events. Significant DO depressions due to BOD in City URO are shown to be only of short duration and infrequent occurrence. A BOD increment in excess of 5 mg/l is forecast only for the interaction of a typical event with 10-year 7-day flow conditions.

TABLE 13-4

FORECAST URBAN RUNOFF AND TREATED SANITARY EFFLUENT, YEAR 2020

	CITY OF SPOKANE				NORTH SPOKANE				SPOKANE VALLEY			
	Annual	Summer Season (2)	24hr-2yr Event (3)	Typ Sum. Event (4)	Annual	Summer Season (2)	24hr-2yr Event (3)	Typ Sum. Event (4)	Annual	Summer Season (2)	24hr-2yr Event (3)	Typ Sum. Event (4)
URBAN RUNOFF												
Volume, Acre Feet (1)	6,943	1,389	404	134	1,618	324	88.9	29.3	2,901	580	158	52.0
Volume, Million Gallons (1)	2,263	453	132	44	527	106	29.0	9.6	946	189	51.4	17.0
BOD, Range (5)												
Max 10^3 Pounds	588	176	41.5	16.6	129	38.8	9.05	3.62	230	69.0	16.1	6.44
Min 10^3 Pounds	294	88	20.8	8.3	64.7	19.4	4.53	1.81	115	34.5	8.05	3.22
Midrange conc. mg/l	23.4	35.0	28.3	34.0	22.1	33.0	28.1	34.0	21.9	32.9	28.2	34.1
Total N, Range (5)												
Max 10^3 Pounds	83.6	22.2	5.55	2.22	18.4	4.90	1.20	.48	32.8	8.72	2.20	.88
Min 10^3 Pounds	41.8	11.1	2.78	1.11	9.21	2.45	.60	.24	16.4	4.36	1.10	.44
Midrange conc. mg/l	3.3	4.4	3.8	4.5	3.1	4.2	3.7	4.5	3.1	4.2	3.9	4.7
Total P Range (5)												
Max 10^3 Pounds	61.6	17.0	12.6	5.03	13.5	3.72	2.77	1.11	24.0	6.64	4.90	1.96
Min 10^3 Pounds	15.4	4.25	3.10	1.24	3.38	0.93	.68	.27	6.01	1.66	1.23	.49
Midrange conc. mg/l	2.0	2.8	7.1	8.6	1.9	2.6	7.1	8.6	1.9	2.6	7.2	8.7
SANITARY EFFLUENT (6)												
Volume, Million Gallons	13,452	4,484	37	9.21	2,904	968	8.0	1.99	4,449	1,483	12.2	3.05
BOD, 10^3 Pounds (7)	2,330	680	5.6	1.4	603	176	1.4	0.35	930	272	2.16	.54
Total N, 10^3 Pounds (7)	1,720	570	4.8	1.2	472	157	1.24	0.31	714	238	1.92	.48
Total P, 10^3 Pounds (7)	520	41	.34	.08	144	11.4	.09	0.022	217	17.2	.13	.033

(1) Runoff volume corresponding to connected impervious area.
(2) June 1 through September 30 during which 20% of annual rainfall occurs and 12 of 49 events occur.
(3) Total event rainfall 1.06 inches, average rate .044 inches/hr.
(4) Total event rainfall 0.35 inches, 13.1 day average between events.
(5) Refer to Table 13-3 for criteria.
(6) Treated effluent to 1983 standards of activated sludge secondary and with seasonal P removal.
(7) Sanitary pollutant quantities are accumulated for periods corresponding to URO periods, respectively: 1 year, 4 months, 1 day and 6 hours.

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TABLE 13-5

URBAN RUNOFF POLLUTION EVALUATION, CITY - YEAR 2020

Urban Runoff Parameter	Annual: Flow - cfs and Average Load-pounds	Annual: Dilution[6] and conc. mg/l[1]	Summer Season: Flow - cfs and Average Load-pounds	Summer Season: Dilution[6] and conc. mg/l[2]	24-Hr 2-Yr Event: Flow - cfs and Average Load-pounds	24-Hr 2-Yr Event: Dilution[6] and conc. mg/l[3]	Typical Event: Flow - cfs and Average Load-pounds	Typical Event: Dilution[6] and conc. mg/l[4]	Typical Event: Dilution[6] and conc. mg/l[3]
Runoff Volume	9.59	.00138	5.75	.00120	204	.10350	269	.2383	.1321
BOD[7]	441,000	.03	132,000	.04	31,150	2.93	12,450	8.1	4.5
Total N[7]	62,700	.005	16,650	.005	4,165	.39	1,665	1.07	.59
Nitrate[8]	-	-	-	-	-	.09	-	.25	.14
Ammonia[9]	-	-	-	-	-	.05	-	.13	.07
Total N[7]	38,500	.003	10,625	.003	7,850	.73	3,135	2.05	1.14
Total Coliform[5]	1	1	-	-	-	10,000	-	24,000	13,000
Lead[10]		.0004		.0004		.03		.07	.04

[1] In mean annual flow of Spokane River per Spokane gage - 6927 cfs.
[2] In mean flow for the summer season, June 1 through September 30 per Spokane gage 4770 cfs.
[3] In mean flow for lowest month of the summer season, September at 1767 cfs per Spokane gage.
[4] In 10-year 7-day low flow of Spokane River at Spokane of 860 cfs.
[5] Based on average conc. in urban runoff of 100,000 org/ml.
[6] Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Stream}}$.
[7] Midrange values from Table 13-4.
[8] At 23% of Total N per Seattle data.
[9] At 12% of Total N per Seattle data.
[10] Based on average conc. 0.30 mg/l per Seattle data.

Maximum forecast incremental nitrate and ammonia levels at 0.14 and 0.07 mg/l are not critical as compared with the respective limiting values of 10.0 and 0.4 mg/l.

Lead is at negligible concentrations for long-term considerations but is at the USPHS limiting value for short-term events.

Total coliform counts due to URO are forecast to cause receiving water concentrations in excess of Class A water limitations for all short-term events.

<u>North Spokane Service Area</u>. Refer to Table 13-6. The Little Spokane River provides less total annual dilution for URO than the Spokane River but provides excellent dilution with low temperature water at critical low flow periods due to the major inflow of groundwater at or near the point of discharge of URO.

The forecast BOD incremental concentrations except for a typical storm event superimposed on 10-year 7-day low flow would result in BOD levels less than 5 mg/l. The length of the Little Spokane River below the point of impact is less than 10 miles. Hence, even at very low flow velocities, the combined URO and streamflow joins the Spokane River in less than 24 hours and therefore water quality of the Little Spokane River will not be impacted by the full amount of 5-day BOD. This condition does not justify BOD abatement measures.

TABLE 13-6

URBAN RUNOFF POLLUTION EVALUATION, NORTH SPOKANE - YEAR 2020

Urban Runoff Parameter	Annual		Summer Season		24-Hr 2-Yr Event		Typical Event		
	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[1]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[2]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[3]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[4]	Dilution[6] and conc. mg/1[3]
Runoff Volume	2.23	.0043	1.34	.00351	44.76	.118	59.01	.168	.1505
BOD[7]	96,850	.09	29,100	.11	6,790	3.32	2,715	5.71	5.11
Total N[7]	13,805	.01	3,675	.015	900	.44	360	.76	.68
Nitrate[8]	-	-	-	-	-	.10	-	.17	.15
Ammonia[9]	-	-	-	-	-	.05	-	.09	.00
Total P[7]	8,440	.006	2,325	.01	1,725	.84	690	1.44	1.29
Total Coliform[5]	-	-	-	-	-	12,000	-	17,000	13,000
Lead[10]	-	.001	-	.001	-	.036	-	.05	.045

[1]In mean annual flow of Little Spokane River per Dartford gage - 316 cfs + 200 cfs groundwater intrusion = 516 cfs.
[2]In mean flow for the summer season, June 1 through September 30 of LSR per Dartford gage - 180 cfs + 200 cfs groundwater intrusion = 380 cfs + URO.
[3]In mean monthly flow for lowest month of the summer season, August 136 cfs + URO + 200 cfs groundwater intrusion = 336 cfs + URO.
[4]In 10-year 7-day low flow of LSR per Dartford gage - 92 cfs + URO + 200 cfs groundwater intrusion = 292 cfs + URO.
[5]Based on average conc. in urban runoff of 10^5 org/100 ml.
[6]Dilution factor = URO mean flow/(receiving water mean flow and URO).
[7]Midrange values from Table 13-4.
[8]At 23% of total N per Seattle data.
[9]At 12% of total N per Seattle data.
[10]Based on average conc. of 0.30 mg/l from Seattle data.

The potential summer season phosphorus enrichment from North Spokane URO is 2325 pounds compared with 11,400 pounds from sanitary effluent treated for P removal.

The forecast nitrate and ammonia incremental concentrations are a maximum of 0.40 and 0.21 mg/l respectively. The nitrate increment is not significant. The ammonia increment is half the limiting value but no other sources are anticipated under the suggested wastewater plan.

Lead is forecast at negligible concentrations under long-term conditions and does not exceed half the USPHS limits for short-term situations.

Total coliform counts due to URO from the North Spokane service area are forecast not to exceed 20,000 org/ml for any short-term events.

Spokane Valley Service Area. Refer to Table 13-7. Considered separately, potential URO from the Spokane Valley is subject to such large dilutions in the Spokane River that the only parameter to exceed limiting values, assuming surface water disposal of all URO, is total coliforms. Potential phosphorus enrichment remains a concern regardless of concentration and is discussed further below.

TABLE 13-7

URBAN RUNOFF POLLUTION EVALUATION, SPOKANE VALLEY - YEAR 2020

Urban Runoff Parameter	Annual		Summer Season		24-Hr 2-Yr Event		Typical Event		
	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[1]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[2]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[3]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[4]	Dilution[6] and conc. mg/1[3]
Runoff V[illegible]e	4.01	.00058	2.4	.0005	79.5	.0431	105.2	.109	.056
BOD[7]	172,500	.013	51,750	.016	12,080	1.22	4,830	3.72	1.92
Total N[7]	24,600	.0018	6,540	.0021	1,650	.17	660	.51	.26
Nitrate[8]	-	-	-	-	-	.04	-	.12	.06
Ammonia[9]	-	-	-	-	-	.02	-	.06	.03
Total P[7]	15,000	.0011	4,150	.0013	3,065	.31	1,225	.95	.49
Total Coliform[5]	-	-	-	-	-	4,000	-	11,000	6,000
Lead[10]	-	.00017	-	.00015	-	.013	-	.033	.017

[1] In mean flow of Spokane River per Spokane gage - 6927 cfs.
[2] In mean flow for the summer season June 1 through September 30 per Spokane gage - 4770 cfs.
[3] In mean flow for the lowest month of the summer season, September at 1767 cfs per Spokane gage.
[4] In 10-year 7-day low flow per Spokane gage at 860 cfs.
[5] Based on average conc. in urban runoff of 10^5 org/100 ml.
[6] Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Water}}$.
[7] Midrange values from Table 13-4.
[8] At 23% of total N per Seattle data.
[9] At 12% of total N per Seattle data.
[10] Based on average conc. of 0.30 mg/l per Seattle data.

At present, Spokane Valley URO is disposed of to groundwater via "dry wells" and general percolation. For percolation disposal, the pollution parameters of concern are those which can traverse the 40 feet or more or percolate through the soils overlying the saturated zone. It is generally recognized that phosphorus and coliforms are subject to substantially complete removals and that BOD is removed to a very large extent. The nitrogen compounds are largely unaffected by the filtering action (it is assumed that application is below the root zone). The removal of heavy metals and organic toxicants is not established.

For constituents that can reach the saturated zone, the concentration in the applied wastewater flow is of concern since the degree of mixing in the groundwater may be small and the percolated wastewater may exist as a relatively unmixed layer on the surface of the native groundwater. On this basis, the concern for nitrates requires examination of the total N concentration in the URO flow itself. This is shown in Table 13-7 to be in the range of 3 to 5 mg/l which is half of the nitrate limitation of 10 mg/l. There is no question that the percolate from URO would represent a degradation of quality in this respect but it would not in itself be in violation of standards.

The concentration of lead in URO is taken as a mean of .30 mg/l based on data obtained in the Seattle area. If concentrations of this order reach the saturated zone, they would constitute a violation of the USPHS standard which is 0.05 mg/l without consideration of ultimate dilution.

Combined Service Areas. Refer to Tables 13-8 and 13-9. The service areas can impact separately only if alternative treatment or land disposal is applied to the other two service areas. Therefore, it is of concern to evaluate the potential pollutional impact from combinations of service areas. Table 13-8 evaluates the combined impact of City

TABLE 13-8

URBAN RUNOFF POLLUTION EVALUATION, COMBINED EFFECT CITY AND NORTH SPOKANE - YEAR 2020

Urban Runoff Parameter	Annual		Summer Season		24-Hr 2-Yr Event		Typical Event		
	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/l[1]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/l[2]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/l[3]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/l[4]	Dilution[6] and conc. mg/l[3]
Runoff Volume	11.83	.00141	7.11	.00126	249	.0856	332	.2418	.1109
BOD[7]	537,850	.03	161,100	.04	37,940	2.42	15,165	8.22	3.77
Total N[7]	76,505	.005	20,325	.006	5,065	.32	2,025	1.09	.50
Nitrate[8]	-	-	-	-	-	.07	-	.25	.11
Ammonia[9]	-	-	-	-	-	.04	-	.13	.06
Total P[7]	46,940	.003	12,950	.004	9,575	.61	3,825	2.08	.95
Total Coliform[5]	-	-	--	-	-	9,000	-	24,000	11,000
Lead[10]	-	.0004	-	.0004	-	.026	-	.073	.033

1 In mean annual flow of Spokane River below LSR confluence per Long Lake gage 8381 cfs.
2 In mean flow for the summer season June 1 through September 30 per Long Lake gage 5630 cfs.
3 In mean flow for the lowest month of the summer season, August at 2661 cfs per Long Lake gage.
4 In approximated 10-year 7-day low flow at Long Lake gage 1041 cfs.
5 Based on average conc. in urban runoff of 10^5 org/100 ml.
6 Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Water}}$.
7 Midrange values from Table 13-4.
8 At 23% of Total N per Seattle data.
9 At 12% of Total N per Seattle Data.
10 Based on average conc. of 0.30 mg/l per Seattle data.

and North Spokane service areas on surface waters of the Spokane River, showing the possible result of Spokane Valley continuing with a land application disposal for URO. Table 13-9 evaluates the combined impact of all three service areas to surface water discharge.

Dissolved oxygen concerns due to BOD in URO appear to be less than critical for both the City plus North Spokane and for all three service areas except for infrequent events of short duration.

The results for nitrates and ammonia for combined service areas include no critical conditions.

Total coliforms for combined service areas exceed Class A requirements for all short-term conditions.

Lead concentrations approach or slightly exceed USPHS limits for all short-term conditions for combined service areas.

The effect on summer season and annual phosphorus budget in Long Lake for combined service areas is of special concern. The estimated

TABLE 13-9

URBAN RUNOFF POLLUTION EVALUATION, COMBINED EFFECT ON ALL SERVICE AREAS - YEAR 2020

Urban Runoff Parameter	Annual		Summer Season		24-Hr 2-Yr Event		Typical Event		
	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[1]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[2]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[3]	Flow - cfs and Average Load-pounds	Dilution[6] and conc. mg/1[4]	Dilution[6] and conc. mg/1[3]
Runoff Volume	15.84	.00189	9.51	.00169	328	.1097	437	.2957	.1411
BOD[7]	710,350	.04	212,850	.06	50,015	3.1	19,995	10.1	4.8
Total N[7]	101,105	.006	26,865	.007	6,715	.42	2,685	1.36	.65
Nitrate[8]	-	-	-	-	-	.10	-	.31	.15
Ammonia[9]	-	-	-	-	-	.05	-	.16	.08
Total P[7]	61,945	.004	17,100	.005	12,640	.78	5,050	2.54	1.21
Total Coliform[5]	-	-	-	-	-	11,000	-	30,000	14,000
Lead[10]	-	.0006	-	.0005	-	.033	-	.089	.042

[1] In mean annual flow of Spokane River below LSR confluence per Long Lake gage 8381 cfs.
[2] In mean flow for the summer season June 1 through September 30 per Long Lake gage 5630 cfs.
[3] In mean flow for the lowest month of the summer season, August per Long Lake gage 2661 cfs.
[4] In approximated 10-year 7-day low flow at Long Lake gage 1041 cfs.
[5] Based on average conc. in urban runoff of 10^5 org/100 ml.
[6] Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Water}}$.
[7] Midrange values from Table 13-4.
[8] At 23% of Total N per Seattle data.
[9] At 12% of Total N per Seattle data.
[10] Based on average conc. of 0.30 mg/l per Seattle data.

natural total phosphorus background in the tributary streams on an annual and summer season basis are as follows:

Stream	Annual Load/Pounds	Summer Seasonal Load/Pounds
Spokane River	769,000	74,000
Hangman Creek	128,000	2,000
Little Spokane R.	37,000	4,600
Total	934,000	80,600

At year 2020 the maximum annual and summer season total P contributions from URO for the three service areas are as follows:

Service Area	Midrange Total P Washoff, Pounds	
	Annual	Summer Season
City	38,500	10,625
North Spokane	8,440	2,325
Subtotal	46,940	12,950
Spokane Valley	15,000	4,150
Total	61,940	17,100

It can be seen that the forecast URO enrichment for the critical summer condition is of the order of one-third of the stream background and approximately one-half of the treated sanitary effluent. The scale of the potential enrichment from URO does not call for abatement as a first line of attack. Reduction of the URO contribution would appear to be appropriate only if the already proposed reductions in the sanitary component prove inadequate. Entire diversion of the Spokane Valley sanitary flow from surface water disposal would reduce the total phosphorus enrichment by as much as 60 percent of the amount of phosphorus in all URO flows. See summary in Table 13-10.

TABLE 13-10

BACKGROUND QUALITY OF RECEIVING WATERS

Parameter	Units	Mean Values Jan-Mar	Apr-June	July-Sept	Oct-Dec
Spokane River at Boundary (RM 96.5)					
Temp.	°C	3.2	10.8	19.0	9.1
D.O.	mg/l	12.1	11.4	8.8	10.2
BOD	mg/l	1.1	2.5	1.9	1.0
Tot. PO_4-P	mg/l	0.048	0.130	0.024	0.024
NH_3-N	mg/l	0.037	0.086	0.051	0.019
Tot. N	mg/l	0.25	0.30	0.29	0.21
Tot. Colif.	No./100ml	518	251	1398	684
Zn. Diss.	ug/l	392	318	168	261
Little Spokane at Mouth (RM 1.1)					
Temp.	°C	5.2	12.4	13.5	7.0
D.O.	mg/l	10.5	8.9	8.8	10.5
BOD	mg/l	1.1	0.8	0.5	--
Tot. PO_4-P	mg/l	0.086	0.084	0.039	0.030
NH_3-N	mg/l	0.077	0.042	0.064	0.042
Tot. N	mg/l	1.300	1.105	1.530	1.206
Tot. Colif.	No./100ml	1802	1012	1776	880
Zn. Diss.	ug/l	42	43	4	15
Groundwater, Primary Aquifer		(Mean Values, Year Around)			
Temp.	°C			10.7	
BOD	mg/l			Negligible	
Total P	mg/l			0.014	
NH_3-N	mg/l			0.015	
NO_3-N	mg/l			1.521	
Total N	mg/l			1.649	
Lead	mg/l			0.019	
Tot. Colif.	No./100ml			None	

Summary of Pollution Abatement Unmet Needs

It is shown above that there are no demonstrable absolute needs for abatement of potential pollution from URO sources in the Spokane urban planning area. All apparent needs are conditional, some dependent upon the as yet unestablished short-term pollution limits and some dependent upon the interaction with other sources of pollutants. The URO phosphorus potential is approximately one-half that from sanitary effluent treated for phosphorus removal. Based on the mathematical simulation of water quality in Long Lake under projected loading conditions and assuming 1983 standards, it is considered that the incremental phosphorus addition to Long Lake represented by untreated URO will not perceptibly influence the level of biomass growth. There is sufficient phosphorus available from other sources to make the URO increment non-critical during the typical spring and fall algal blooms. The quantity of phosphorus added typically during the intervening summer period from URO sources is insufficient to influence the level of biomass during this period. The heaviest phosphorus contribution from URO occurs during the period of higher river flows and lower temperatures when phosphorus concentration is not limited to biological growth.

Considering the enormous difficulty of trying to treat URO for phosphorus removal by present technology, other alternatives would deserve first consideration if further reduction in the phosphorus budget were found necessary. Diversion of URO to either land application or groundwater disposal are two possibilities. Although phosphorus abatement from URO sources cannot be identified at this time as an absolute need, the potential attack on this source through land application or groundwater disposal should be kept in mind while selecting alternatives.

There is no doubt that URO reaching surface waters in large quantities will cause short-term conditions of total coliform counts that are in excess of Class A stream standards. The public health consequences of these short-term excesses are a function of the specific kind of recreational demands that are being put on the receiving waters. If there is a need to have the receiving water available for unrestricted body contact recreation such as swimming at all times, including periods of inclement weather, abatement by disinfection is required. Disinfection by clorination, however, must be recognized as creating a threat to use of the stream as a fish habitat. The risk in creating excessive chlorine residuals or toxic chlorine compounds is much higher where application is to highly variable uncontrolled URO. Although an absolute unqualified need for disinfection cannot be identified, selection of action plans dealing with URO should recognize the potential need by providing the means, such as storage, to make disinfection feasible or avoid surface disposal through percolation.

The short-term threat of toxicants to surface water, exemplified above by lead, is marginal in an absolute sense when compared with long-term standards and further because the standards are uncertain.

Pollution Reduction Alternatives

General. There does not appear to be an immediate mandatory need for reduction in pollution due to URO, considered for itself alone and not as an element of combined overflow. Whether required or not, reduction in pollution potential is desirable for its own sake. Some of the more effective techniques for URO pollution control are non-structural or are incidental to normal drainage needs. Also, the effectiveness of structural treatment methods, if ever required by future criteria, are in many cases dependent for their success upon conditions built into the collection system. For these reasons it is well to explore the available techniques for reduction of URO pollution, with particular attention to non-structural methods and conditions which will facilitate possible future treatment. The field of URO pollution abatement elements is summarized in Table 13-11.

Non-Structural Alternatives. The non-structural alternatives with the greatest potential are impervious surface connection regulations and surface housekeeping. Impervious surface connection regulation consists of minimizing the direct connections of impervious surfaces to the collection system to provide greater opportunities for pollutant reduction through overland flow, surface storage and percolation. The built-up density and configuration of surfaces usually limits application of this method.

Surface housekeeping, mainly street sweeping, is one of the most effective methods of reducing the URO pollution load. This has been amply demonstrated in sampling by the significantly lower concentrations of pollutants in flows from well maintained areas.

Structural Alternatives. These alternatives fall into three categories: storage, treatment and percolation. Storage provides treatment in itself through sedimentation, but the most important function of storage is reduction of attenuation of the high peak flows characteristic of URO. Reduction of the high peaks reduces impact by spreading the pollutant load over a longer period of time, if released untreated, and greatly reduces the cost and increases the effectiveness of treatment. The large number of ways that can be used to create more storage are most effective if kept in mind during the early stages of system development. The lack of storage and storage opportunites in the City is going to make any approach to URO pollution reduction difficult and costly.

Treatment techniques applicable to large flows which persist for relatively short times have been sought recently under a number of research programs sponsored by EPA. The search has concentrated on removal of suspended solids through such processes as screening, microscreening, flotation and filtration. Truly effective, reliable and

TABLE 13-11

POLLUTION ABATEMENT ALTERNATIVES
FOR SEPARATED URBAN RUNOFF

Method	Alternative
Non-Structural	1. Land use control
	2. Impervious surface connection regulation
	3. Regulation of construction operations
	4. Litter laws and enforcement
	5. Surface housekeeping (street sweeping, etc.)
	6. Use of unleaded gasoline
Structural	1. In-system storage
	a. Ponding in streets and parking areas
	b. Rooftop ponding
	c. Ponding structures
	d. Oversized conveyance systems
	e. Conveyance system regulating structures
	2. Terminal storage
	3. Groundwater recharge
	4. Treatment, separate
	a. Sedimentation
	b. Skimming
	c. Screening
	d. Flotation
	e. High rate filtration
	f. Microstraining
	g. Chlorination
	5. Treatment with sanitary sewage

economical techniques for general application are not yet available. All of these techniques although directed toward use at high flows, benefit greatly by peak attenuation afforded by storage ahead of the process.

Removal of a significant proportion of suspended solids is essential to effective disinfection since organisms protected by inclusion in particulate matter escape the attack of disinfection chemicals. Sharp flow peaks and rapidly changing rates of flow are also detrimental to effective disinfection since they make control of chemical application

difficult. Poor control in proportion to flow can result either in failure to achieve disinfection through underdosing or toxic conditions for fish in the receiving waters due to overdosing. Thus, disinfection, which is one of the most important needs, is one of the more difficult objectives to obtain. Note again the need for peak attenuation and suspended solids removal which can be achieved by storage.

Percolation can be regarded as both a treatment method and a disposal technique. Few locations have the soil characteristics that make this technique feasible. This study area is uniquely favored in this respect. Even the high rates of percolation possible in this area may not be enough to utilize available areas without the aid of storage to provide additional time. The ideal application combines storage and percolation at the same site.

Suggestions. Urban drainage management should recognize the potential benefits of planning for reduction of URO pollution through non-structural measures regardless of specific present or critical need. Design of drainage facilities should consider the benefit of taking all opportunities to include storage and percolation so that treatment, if necessary, will be feasible.

Urban Runoff Pollution Abatement Conclusions

General. The basic conclusion to be derived regarding specific treatment of separated URO to control this vector of water pollution is that it is not justifiable at this time by need. In addition it is concluded that the present unsolved technical complexities of providing reliable and significant pollutant removals other than by non-structural methods, storage or percolation are such as to raise serious questions as to the wisdom of applying physical or chemical treatment measures. This conclusion suggests that present emphasis should be on source control of URO pollutants, which supports the concept of storm/sanitary sewage separation at the source and suggests that good "housekeeping" appears to be the most cost-effective means of effecting reduction in surface runoff pollutants.

City Service Area. Since the City is committed to a detailed plan of study for solution of the combined sewer and associated internal flooding problems, the objectives here are to point out the implications of URO pollution potential that should be considered in these studies. As shown above, the primary abatement needs relative to the URO component of City wastewater flows are:

1. Removal of unsightly floating materials and scums.

2. A small reduction in BOD impact.

3. Disinfection.

4. Reduction in lead content.

The impact from the sanitary component of combined flow, particularly grease which forms floating scum, BOD due to stranded solids and high coliform content are judged to be more serious than the URO component and continue to deserve highest priority in the alternatives for dealing with combined sewer problems. There appears to be no incentive to route URO flows through complete treatment for their own sake.

The alternatives mentioned for consideration in the City Plan of Study are evaluated as follows for their respective values in meeting URO pollution abatement needs:

1. Storm relief sewers with satellite treatment facilities, no storage.

   This alternative would treat unregulated combined flow by one of the several methods feasible for highly varying flow and highly intermittant operation. The feasible treatment alternatives are:

   a. Screening
   b. Flotation
   c. Chlorination

   This alternative could satisfy the need for removal of unsightly floating materials and for disinfection. It probably could not achieve any reduction in BOD below that which would be obtained in completely separated untreated urban runoff, due to the inclusion of a significant sanitary component. The lack of storage to regulate flow would provide poor control of chlorination and introduce risks of toxicity due to overchlorination or escape of coliforms due to underchlorination and the fact that many coliforms would be carried through with particulate matter. This alternative would provide no opportunity for phosphorus reduction if needed and would do nothing for toxic material control.

   This alternative is rated as the least satisfactory of the four.

2. Storm relief sewers with storage so that all potential overflows can be stored for later conveyance to the STP through existing interceptors.

3. Storm relief sewers combined with relief interceptors and further enlargement of the City STP.

   These alternatives would produce the maximum reduction in urban runoff pollution impact by giving it full treatment or at least primary treatment along with sanitary flow. The only defect of this alternative is that it provides a

higher degree of treatment than is necessary from a functional standpoint and perhaps more than may be required under regulations for URO when promulgated.

4. Complete storm and sanitary separation with direct untreated discharge of storm waters.

   From an overall pollution abatement standpoint, this alternative has high value since it gives the most complete treatment to the sanitary component which is the more significant load. It does not of course provide any abatement of urban runoff pollution potential but has the advantage of making these flows separately available for the appropriate level of treatment to be added.

It is suggested that the complete separation alternative where used consider location of the terminations at places where treatment and/or storage could be added and where the overflow from treatment could be pumped into the sanitary collection system for ultimate disposal.

5. A fifth alternative that should be considered is the addition of storage to Alternative 1. This would remove most of the disadvantages of 1 and raise it to a high degree of acceptability.

From a functional URO pollution abatement standpoint, Alternatives 4 and 5 with storage and treatment added would be leading candidates. The ideal treatment would result in effective removal of floating materials and scums, a moderate reduction in BOD, and sufficient flow regulation and removal of particulate matter to make chlorination a well-controlled process.

Where large volumes of storage are not feasible, even token storage to catch the first flush for selected treatment or later diversion to the sanitary system would be very beneficial.

Non-structural measures should not be neglected. Of prime importance where combined sewers are retained is the possibility of keeping the sewers cleaned during dry weather so that the impact of a storm is not heightened by the flush of accumulated materials. Likewise, consideration should be given to the potential for urban load reduction through housekeeping reduction of surface loading through street sweeping and other controlled cleaning measures.

One of the most critical design needs for the City study is a means of sizing storage in full recognition of statistical requirements. It is suggested that a computerized statistical analysis be implemented for this purpose.

North Spokane Service Area. North Spokane has started on a separated system of storm and sanitary sewers. It is suggested that all future

construction follow this criterion so that the appropriate level of treatment can be applied in a most cost-effective manner to each component.

The most cost-effective adjunct to URO pollution control where space is available is storage. The natural point for such a storage facility or facilities is in the lowlands bordering on the Little Spokane River. Use of a portion of these lands for temporary storage and/or percolation of URO would be compatible with land use planning.

Adequate storage and particularly storage with percolation would provide the following benefits:

1. Protect the lower Little Spokane River from dissolved oxygen sag due to BOD from URO.

2. Protect the recreational use of the Little Spokane River from coliform discharges from URO.

3. Remove the phosphorus potential by percolation to further reduce Long Lake enrichment.

4. Reduce any possible impact of ammonia through attenuation by time.

5. Reduce lead escape through percolation and/or spreading impact over longer time.

Adequate storage would probably preclude the need for any further treatment other than provision for surface skimming and possibly chlorination. If the storage can be made large enough and percolation adequate, it is possible that the ponds could be operated on a non-overflow basis.

Flow control alternatives are summarized below for the North Spokane storm drainage plan which includes supplemental storage. This in-system storage can also contribute toward water quality improvement. These flow control plans indicate a number of possible storage and infiltration-percolation sites including Cedar Road-Francis Avenue and the existing low area immediately north of Whitworth College. The Whitworth sites would require diversion piping to be constructed, which would divert all or a portion of storm drainage flow through an essentially natural storage/sink area.

Spokane Valley Service Area. The major alternative consideration for the Spokane Valley service is whether to continue local disposal to percolation, taking advantage of removals provided by the soil, or to construct a collection system prior to either surface water or limited locations for percolation.

It is suggested that urban drainage continue to be disposed of to the largest possible extent by percolation to groundwater in small increments as near to the place of origin as possible. This obviously protects the Spokane River from BOD, coliform and phosphorus impacts. The soil depth to groundwater is expected to protect the groundwater from BOD, coliform and phosphorus impacts. The only groundwater quality concern not directly addressed by the method is possible mineral or organic toxics. Since the extent to which these items are removed by the soil is uncertain, it is suggested that vigilance against these items be maintained by non-structural methods including monitoring and control of the use of these materials in the community and industry. At present, the only mineral toxicant of concern is lead from motor fuels, and its identification is from literature sources only. Available data for the groundwater of the study area does not indicate any percolation impact of lead.

Urban Runoff Flow Control

City of Spokane. The City north of the Spokane River has generally adequate natural slope for drainage but no distinct natural system of drainage channels. The existing system of combined sewers generally follows the natural ground slope pattern. Drainage problems within the City exist due to lack of sewer capacity and in some cases deliberate ponding to minimize peak wet weather flows in the combined sewers. South of the Spokane River the drainage pattern is more typical in that there are areas in which there are natural drainage channels. There are also areas of swamp and spring outcrops. Here the combined sewer problem is compounded by the presence of infiltration flows, some of which derive from deliberate drainage of springs. Refer to the study[1/] of infiltration-percolation, prepared by the City's consultant, directed toward solution of these existing internal flooding problems concurrent with resolution of the combined sewer overflow problem.

North Spokane. Certain locations in North Spokane currently experience flooding due to a combination of runoff from urban development and runoff from presently undeveloped areas which must pass through developed areas. There is a natural drainageway through the North Spokane development that has been improved as an urban drain. This drainage discharges into the Little Spokane River, but does not serve the entire area. Portions of developed area suffer from flooding from three causes. One cause is encroachment on and restriction of the primary natural drainage path that extended through the area. This first cause is aggravated by the second cause, namely, the increase in runoff due to development. The third cause is topographic, resulting from local low spots that do not have natural surface drainage.

[1/] Bovay Engineers, Inc., Spokane Wastewater Treatment Plant, Report on Excessive Infiltration/Inflow, 1974.

These drainage problems of the North Spokane area have been the subject of preliminary investigations conducted by the County Engineer's Office. The basic drainage problem is that a significant portion of the natural drainageway is on private property and it is this section that experiences flooding of the adjoining development. Rather than try to increase the capacity of the section through private property, the alternative solutions all involve methods for diverting sufficient upstream flows before they reach this section to maintain flows which will not cause nuisance or damage. There are no available estimates of historical damage for either the main drainageway or for the local low areas. The gravel pits northwest of the intersection of Francis Avenue and Cedar Road are one of the physical features of the area considered in the County alternatives. These pits are considered for possible use as retention and percolation ponds for all or a portion of the runoff from the tributary area on Five Mile Prairie. Plan alternatives generally provide for increasing capacity of the primary drain to convey storm flows through the area of development to a point where increased natural channel capacity can adequately convey flows to the Little Spokane River.

In order to select the optimum storm drainage flow control plan for North Spokane, additional planning and design data and implementation decisions are required. The following action plan is suggested:

1. Complete an inventory of existing drainage facilities in the area. There is no existing complete compilation of existing facilities including County, private developer, Rural Improvement District, State (associated with Highway 395) and City.

2. Complete a maximum "no damage" and a maximum "nominal inconvenience" water surface for the natural drainageway and the associated flow capacity for each.

3. Complete a detailed inventory of unmet needs for drainage relief throughout the area.

4. Make physical flow measurements of the existing rainfall-runoff relationship for the Five Mile Prairie tributary area.

5. Make physical measurements of the infiltration capability of the existing gravel pits.

6. Establish design criteria for analysis.

   a. Level of future development to be provided for in Five Mile Prairie and related surface imperviousness.

   b. Level of protection and return period of conditions which cause damage or inconvenience.

c. Methodology for runoff calculations and hydrograph volumes.

7. Eatablish a working relationship between City and County for presentation of alternatives to the County Commissioners and City Council.

8. Prepare an overall integrated drainage plan for the entire area before undertaking any piecemeal solutions.

9. The overall drainage plan should consider minimizing the impact of urban drainage on surface water quality. The location of the terminus of the natural drainageway at the Little Spokane River appears to present an opportunity for storage in the flood plain which could be utilized to effect economical treatment for the primary concern of bacteriological contamination.

10. The overall drainage plan should consider non-structural alternatives for minimizing increases in runoff from future development by regulation of such development to utilize on-site retention.

Spokane Valley. At present, with a few minor exceptions, substantially no urban runoff reaches the Spokane River from the existing urban development.

Although there were and are no natural streams on the surface of the Spokane Valley due to the highly permeable soil, the topography has a configuration similar to land shaped by surface runoff, consisting of a system of low ridges and swales paralleling the river and converging on a natural point of concentration in the vicinity of the east end of Felts Field. Therefore, any collection system for urban runoff would necessarily follow these land forms. The potential for flooding due to urban runoff is related to these same land forms. Once the collection process is started, any inadequacies or failures of the system would be concentrated along the bottom of these swales. At present there are no valley floor collection systems, all runoff disposal being to dry wells or surface percolation. In general, these facilities provide adequate drainage.

Other than maintenance problems to prevent clogging in dry wells, the major surface drainage problems of Spokane Valley involve development around the periphery of the valley and development involving encroachment on natural sink areas. Two distinct, but related, drainage problems are developing in these areas. One situation involves development from the valley floor up into the bordering slopes in an area of relatively impervious soil where some storm sewers have been constructed. The other situation is where there is already unsewered development on the valley floor and development is beginning in the bordering slopes.

The first situation is exemplified by County Road Project 1101 in Elton Road above Upriver Drive. There is a large undeveloped area above this storm sewer project which picks up the natural runoff from the undeveloped lands and conveys it and local drainage through developed lands on the valley floor. An example of future conditions is presented in the proposed Northwood addition which will become tributary to this existing storm drain system. If uncontrolled, the new development in previously undeveloped area will increase the peak flow reaching the storm drain system. A small increment like Northwood will probably not overtax the existing facilities. But a succession of similar developments will eventually exceed the capability of the downstream system.

The second situation is demonstrated by areas further east in Pasadena Park where the valley floor extending from the boundary slopes is permeable and has been developed without storm drainage systems. When development takes place in the relatively impermeable bordering slopes, the resultant increased runoff is confronted with development which has encroached on the natural sink area of the pervious valley floor. When the runoff becomes large enough or the area for percolation small enough, flooding is the result. A proposed new subdivision northwest of Argonne Road and Wellesley Avenue has been approved by the Spokane County Planning Commission contingent upon a solution of the storm runoff disposal problem by on-site percolation.

This particular development is fortunate and unique in that it extends onto the permeable valley floor far enough to provide its own percolation area. This will not be true for most future development in the bordering slopes which will be confronted with a valley floor already developed.

These conditions are typical of almost any existing or potential development area on the rim of the valley and suggest that an effective, uniform policy should be developed to provide control of drainage from these areas.

The most critical storm drainage flow control problem in Spokane Valley involves the sink area of Plouf Creek and the needs for improved drainage for newly developing residential areas which are adjacent and tributary to this sink area.

The tributary drainage area of Plouf Creek upstream from Schafer Road is larger than that of Liberty Lake, but the creek has no surface outlet to the Spokane River and does not result in a lake. The entire flow percolates into the valley gravel. The locations at which the percolation takes place are not known but the surface flow does not appear to extend north of 26th Avenue.

When flows are high and in excess of percolative capacity the waters pond and spread out over adjoining low land from south of Schafer Road to the vicinity of 26th Avenue. This causes inconvenience flooding of ten residential lots in Chester. There is serious concern by the County that percolative areas will be blocked by filling, as is now taking place both north and south of Schafer Road or that development itself will take place in the ponding areas. This concern is compounded by present intentions of the County to construct road paving and related drainage systems for new residential development in the foothills immediately adjacent to the sink area. This improvement was requested by owners and will accelerate the quantity of drainage conveyed to the sink area which already causes inconvenience and damage for which additional liability could result. At present, the lands are private property and there are no drainage easements or zoning restrictions on use or development.

The foregoing specific but typical examples of growing concern in Pasadena Park and Plouf Creek call for the formulation of a general policy to deal with these situations before they become critical problems. A suggested plan of action is as follows:

1. Develop a master drainage plan for the bordering slopes of the entire valley which recognizes the present and forecast runoff and provides for its disposal by one or more of the following alternatives:

   a. Restriction of development on the historic percolation area.

   b. Substitution of an alternative percolation area or subsurface leaching.

   c. Extension of drainage conduit to the river.

2. Develop a policy for storm drainage of slope areas that recognizes the requirements for capacity in these systems to accommodate forecast runoff.

3. Investigate the legal problems that are inherent in both the structural and non-structural aspects of these policies. For example:

   a. to what extent a downhill developer is obligated to provide excess capacity in his system to accommodate flows due to future development.

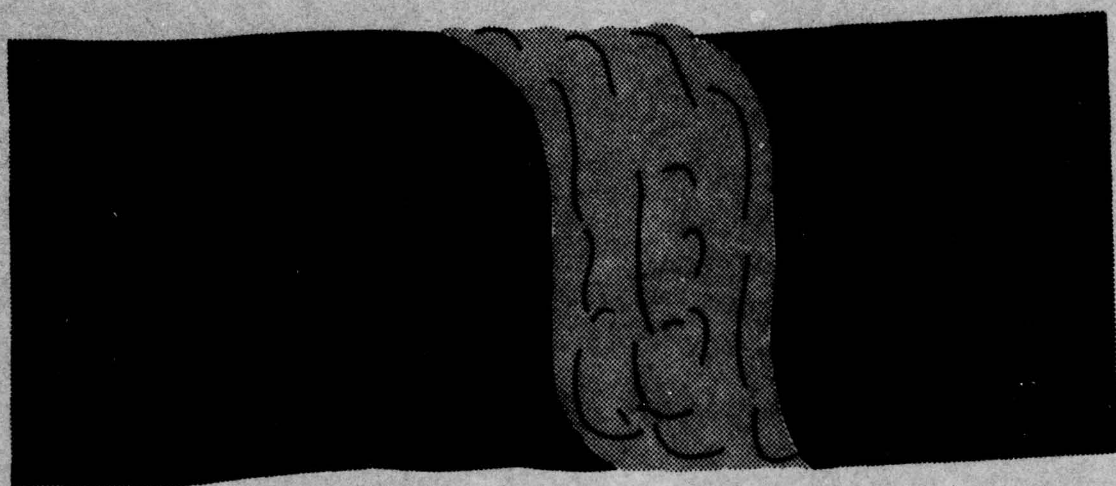
   b. how property owners can be obligated to reserve certain areas for percolation of runoff flows generated off of their property that may or may not have percolated in that specific site.

Institutional and Financial Considerations

The institutional and financial needs for the abatement of flooding problems due to urban drainage are substantially the same as those for flood control discussed in the previous section. The same conclusion would be reached, namely that the City and County have all the necessary planning, regulatory and financing powers either of themselves or through formation of local improvement districts.

The urban drainage problem in North Spokane has special considerations in that City-County cooperation is required. The cooperative approach here could be similar to that discussed under wastewater management.

Spokane Valley problems are unique in the approach required for preservation of natural percolative areas to serve drainage from adjoining impervious slopes. There are legal questions here, beyond the scope of this study, that require solution before either regulatory or acquisitional solutions are attempted.



SECTION 14

WATER SUPPLY

14. Water Supply

Overview

Water resource development in the study area is characterized by almost exclusive reliance on groundwater. The uniquely favorable characteristics of the primary Spokane Valley (SV) aquifer has been the magnet that has drawn residential, industrial and irrigated agricultural development to its surface. The boundary of this aquifer generally corresponds to the boundary of intensive development in the study area. Even in areas away from the SV aquifer, the predominant source is groundwater. Out of a total annual use of 158,880 acre feet for the study area, 146,130 acre feet are supplied from groundwater. Of this groundwater source, 129,330 acre feet are supplied by the SV aquifer.

The groundwater resources of the study area can be considered in three catagories: the primary aquifer of the Spokane Valley, the basalt aquifer of the Columbia Plateau and all other aquifers including those of the Little Spokane River and Chamokane Creek Valleys. The SV aquifer is a deep valley fill of glacial outwash gravels supplied by recharged sources outside the study area with an estimated mean annual groundwater flow entering the study area of the order of 1000 cfs. The basalt aquifer consists of horizontal layers of fractured rock interlayed with relatively impermeable materials in which the machanism of recharge is not well understood and the rate of recharge is estimated to be small. Aquifers in the Little Spokane and Chamokane Valleys are gravel deposits recharged from local streams.

The significant uses of surface water are limited other than for non-consumptive uses such as hydroelectric power generation, maintenance of fishery resources and recreation. There is some use for irrigated agriculture, primarily in the Little Spokane Valley, and the industrial cooling use by Kaiser Trentwood in the amount of 6387 million gallons per year or 19,600 acre feet of Spokane River water. This water is used in a once through cooling system and returned to the Spokane River immediately downstream from its point of diversion. In effect, it is not a consumptive use of water.

Another characteristic of the study area is the large number of water suppliers and users with individual sources. There are 175 or more purveyors and users with individual supplies, not counting individual dwellings or farms with their own supply. Of this number, 42 are agency purveyors of water and the remainder cover a wide variety ranging from industries and large government-owned facilities through developer's systems to parks, a motel, mobile home parks and schools.

Considering the agency purveyors, the City Department of Utilities is the dominant agency serving approximately 175,000 persons out of a total of approximately 290,000 persons in the study area. Eighteen agencies have service populations ranging from 1000 to 17,000. There are 23 agencies of various sizes, including the City, which draw from the SV aquifer.

There are only 39 significant industrial water users in the study area, all located in the urban planning area and all, except for the Kaiser Trentwood cooling and process water, supplied from the primary aquifer. Of these 39, 32 are supplied with all or part of their needs from municipal systems, seven provide all their own needs from individual wells and ten supplement their municipal supply with individual wells.

Irrigated agriculture, like residential development and industrial development, is located predominantly on the SV aquifer. The largest concentration is in the valley east of the City. A smaller concentration is north of the City. In the eastern part of the valley the agricultural demand is supplied primarily by irrigation districts. In all other areas, the agricultural demand is supplied from private wells. The amount of water and the number of acres irrigated from private wells can only be estimated from DOE water rights records.

Of the total amount of water used in the study area, the division between classes of use is as follows:

Class of Use	Total Annual Use Acre Feet
Domestic	96,740
Industrial	24,580
Agricultural irrigation	35,960
Non-agricultural irrigation	1,600
TOTAL	158,880

In the above table, the industrial component again is stated excluding the Kaiser Trentwood cooling water use.

The domestic component contains a significant irrigation component, as is evident from the pattern of annual use, which exhibits a heavy peak in summer. The domestic use of water for irrigation in summer appears to be of the same order of magnitude as the total irrigated agriculture use. Per capita domestic use for the City is 290 gpcd annual average with 183 gpcd for the winter months and 430 gpcd for the summer months. These per capita rates also are indicative of the heavy irrigation use associated with the domestic supply.

Domestic Water Systems

Number and Kinds of Systems. There are approximately 175 separate domestic water systems in the study area exclusive of those which serve a single residence. These systems range in size from that of the City which serves a population of 175,000 down to systems which serve a motel or campground.

These domestic water systems are operated by a variety of governmental agencies and private enterprises. The system operators in the study area are listed in Table 14-1.

Summary data consisting of population served, number of services, average daily demand and source of water supply are shown in Table 14-2 by category.

Municipal Systems. There are 11 municipal systems in the study area as listed in Table 14-1. All are in Spokane County except Tekoa, which is in Whitman County. Approximately 62 percent of the study area population is served by municipal systems of which the City alone represents 57 percent. All municipal systems except the City and Millwood are in isolated communities and are not in the SV aquifer.

The City serves a population of approximately 175,000 with a major complex water facility. In addition to supplying water for domestic use, the City also supplies all or a part of the use of industries located inside its service zone. The City provides a part of the supply for Washington Water Power (WWP) Service Area Nos. 1, 3A and the Whitworth Water District, and all of the supply for WWP Service Area No. 4. Small portions of the City in North Spokane are served by the Whitworth Water District and WWP Areas outside the City that are served include WWP Zone No. 4 and some of the Moran Prairie Area.

The source of water for the City system is the SV aquifer. A total of 17 wells tap this aquifer with an aggregate installed pumping capacity of 171,000 gpm from 30 pumps. Much of this capacity is concentrated in the eastern part of the City near Spokane Dam, a city-owned hydroelectric generating facility which provides electric power for the well pumps. Other significant concentrations are located at the Hoffman, Grace and Nevada sites.

The City distribution system is subdivided into 15 pressure service zones and includes 19 storage reservoirs with total storage of 85,615,000 gallons served by 15 booster pumping stations. Chlorination is provided for all water served by the City.

Water Districts. There are five water districts in the study area. Colbert and Four Lakes are newly organized as water districts but their predecessor agencies had been water purveyors. The water districts are

TABLE 14-1

PRINCIPAL DOMESTIC WATER SERVICE ORGANIZATIONS

Category	Name	DSHS Number
Municipal Water Departments	Airway Heights	00650
	Cheney	12400
	Deer Park	18500
	Fairfield	24450
	Latah	46150
	Medical Lake	53400
	Millwood	54850
	Rockford	73550
	Spangle	82870
	Spokane	83100
	Tekoa	87300
Water Districts	Colbert W.D. No. 9	-
	East Spokane W.D. No. 1	21650, 06265
	Four Lakes W.D. No. 10	26200
	Irvin W.D. No. 6	36050
	Whitworth W.D. No. 2	96600, 96603, 96607, 28000
Irrigation Districts	Carnhope I.D. No. 7	11250
	Consolidated I.D. No. 19	10220, 10223, 10228, 10232, 10236, 10240
	Hutchinson I.D. No. 16	35100
	Moab I.D. No. 20	55440
	Model I.D. No. 18	55550
	North Spokane I.D. No. 8	61300
	Orchard Ave. I.D. No. 6	64000
	Pasadena Park I.D. No. 17	66300
	Trentwood I.D. No. 3	89250
	Vera I.D. No. 15	91450
Private Water Companies	Dishman Water Co., Inc.	19450
	Greenacres Waterworks	29650
	Lakeridge Water Co.	45120
	Liberty Lake Utilities Co.	47150
	Milan Water Co.	-
	Modern Electric Water Co.	55600
	North Mountain View Water Co., Inc.	60780
	Pleasant Prairie Water Co.	67880
	Rivilla Water Corp.	73050
	Washington Water Power Co.	93350, 93351, 93352, 93354, 93355, 93356, 93357, 93358, 93360, 13450
	West Shore Water Co., Inc.	95450
Water Associations and Cooperatives	Balmer's Garden Community Water Sys.	04179
	Cedar Knolls Water Association	11935
	Elk Water Association	22915
	Glenrose Water Association	28135
	Liberty Lake Improvement Club	47145
	Marshall Community Water Assoc.	51845
	Waverly Heights Water Assoc.	93820
Federal	Fairchild Air Force Base	24350
	Bureau of Indian Affairs, Wellpinit	-
State	Eastern State Hospital	21850
	Eastern Washington State College	21900
Other Categories	Residential Developments	-
	Mobile Home Park	-
	Resorts and Campgrounds	-
	Schools	-
	Golf and Country Clubs	-
	Motels	-

TABLE 14.2

DOMESTIC WATER USE BY INDIVIDUAL SYSTEMS

Agency	Ownership	Population	No. Water Services	Avg. Daily Demand, Gal.	Sources by No. of Wells SV Aquifer	Other Ground Water Sources	Per Capita Use gpcd.
Airway Heights, Town of	Municipal	1,197	283	153,000	-	4	128
Cheney Water Department	Municipal	6,500-10,000	1,267	1,000,000	-	4	100-154
Deer Park, City of	Municipal	1,350	602	352,000	-	4	261
Fairfield Water Department	Municipal	514	231	150,000	-	3	291
Latah, Town of	Municipal	169	84	52,500	-	1	311
Medical Lake Water Department	Municipal	1,872	578	408,000	-	-	218
Millwood Water Department	Municipal	1,800	600	263,000	3	-	146
Rockford Water Department	Municipal	367	154	43,000	-	1	117
Spangle, Town of	Municipal	212	87	53,000	-	2	250
Spokane Department Utilities	Municipal	175,250	54,972	50,760,000	16	1	290
Tekoa, City of	Municipal	808	343	200,000	-	3	248
Colbert W.D. #9	Water District	210	60	34,600	-	1	165
East Spokane W.D. #1	Water District	3,200	900	271,000	3	-	85
Four Lakes W.D. #10	Water District	200	51	8,000	-	2	40
Irvin W.D. #6	Water District	1,650	550	210,000	3	-	127
Whitworth W.D. #2	Water District	8,908	2,581	1,190,000	7	2	133
Carnhope I.D. #7	Irrigation District	1,400	459	1,000,000	1	-	714
Consolidated I.D. #19	Irrigation District	6,500	1,702	7,240,000	34	-	1,114
Hutchinson I.D. #16	Irrigation District	2,100	693	262,000	2	-	125
Moab I.D. #20	Irrigation District	167	67	94,500	1	-	565
Model I.D. #18	Irrigation District	4,075	1,200	575,000	4	-	141
North Spokane I.D. #8	Irrigation District	1,900	654	405,000	4	-	225
Orchard Avenue I.D. #6	Irrigation District	3,500	1,000	1,045,000	2	-	299
Pasadena Park I.D. #17	Irrigation District	2,000	670	1,644,000	3	-	822
Trentwood I.D. #3	Irrigation District	3,400	837	1,550,000	5	-	456
Vera I.D. #15	Irrigation District	11,000	2,920	6,490,000	7	-	590
Dishman Water Co.	Private Co.	500	117	60,000	1	-	120
Greenacres Water Works	Private Co.	790	225	52,000	1	-	66
Lakeridge Water Co.	Private Co.	65	27	5,250	-	2	124
Liberty Lake Utilities Co., Inc.	Private Co.	900	386	500,000	-	2	556
Milan Water Co.	Private Co.	50	15	7,500	-	2	150
Modern Electric Water Co.	Private Co.	14,588	4,168	2,290,000	9	-	157
N. Mt. View Water Co.	Private Co.	18	5	3,000	-	1	150
Pleasant Prairie Water Co.	Private Co.	34	10	14,000	1	-	412
Rivilla Water Corp.	Private Co.	97	25	15,000	-	1	150
Washington Water Power Co.	Private Co.	17,900	4,635	3,320,000	13	10	185
Thirty-five Small Companies, mostly Private Development		1,503	494	332,000	-	-	221
Fairchild A.F.B.	Federal	15,097	2,043	2,100,000	3	1	133
Wellpinit	Federal & BIA	50	10	10,000	-	2	200
Eastern State Hospital	State	3,580-6,500	5	750,000	-	2	115-195
E. Washington State College	State	4,000-7,000	30	833,000	-	2	119-208
Spokane International Airport	Airport	1,500-3,000	26	465,000	-	2	155-310

scattered geographically with two north of the City, two east and one southwest. The largest are in the urban area, with Whitworth Water District #2 serving approximately 9000 and East Spokane Water District #1 serving approximately 3200.

Irrigation Districts. There are ten irrigation districts in the study area and all except one are located east of the City in the Spokane Valley. Irrigation districts (ID) are the second largest category of domestic water purveyors. Despite the implication of the name "irrigation," these districts are, with three exceptions, predominantly in the business of providing water for domestic use rather than for large scale commercial agricultural irrigation. The exceptions are the Vera, Consolidated and Moab IDs which serve major agricultural areas. Urbanization of former agricultural lands has transformed the character of other districts. As will be discussed under water use, these urbanized areas of former agricultural lands still retain some characteristics of irrigation use due to the large land parcels which are irrigated for horse pasture and small scale growing and landscaping.

The following six IDs are similar in their location, source of water and the fact that they have very minor if any agricultural irrigation use. All are in the Spokane Valley east of the City and derive their water supply from wells to the SV aquifer.

District	Population Served	DSHS No.
Carnhope	1400	11250
Hutchinson	2100	35100
Model	4075	55550
Orchard	3500	64000
Pasadena	2000	66300
Trentwood	3400	89250

Vera and Consolidated are the two largest IDs and Consolidated is the largest agricultural irrigator.

Vera ID is located 7 miles east of the Spokane city limits on the south side of the valley and serves a population of 11,000. Agricultural irrigation accounts for 25 percent of the annual water use. There are three separate service systems; domestic, spray irrigation and ditch irrigation. There is a single pressure zone in the domestic system.

The Consolidated ID which serves 6500 persons consists of seven geographic service areas strung through the Spokane Valley from the vicinity of Trentwood to the State line. Only one area is contiguous to another. Consolidated was organized from the U.S. Bureau of Reclamation Spokane Valley Project. Only 38 percent of the current annual deliveries are for domestic use. The remaining 62 percent are used for agricultural irrigation of approximately 2600 acres of land.

Private Water Companies. This category should be more formally classified as stock holder owned or private enterprise owned to make the distinction from those which are owned by a government agency or by the customers themselves, as is the case for mutuals or cooperatives.

There are 11 companies in this category ranging in size from a service population of 16 to over 17,000. Two companies, Modern Electric Water Company and WWP, dominate this category with service populations of over 14,000 and 17,000 respectively. Of the remaining nine, six have service populations of less than 100 and three have service populations between 100 and 1000.

The service area of Modern Electric covers an area in the heart of the Spokane Valley beginning less than two miles east of the City boundary and including a large part of the communities of Dishman and Opportunity. The service area covers what was the site of the initial irrigated agriculture in the valley and the company was originally organized to provide irrigation water.

Modern Electric is stockholder owned but the stock distribution and ownership are tied to land ownership within the service area. Therefore it has aspects of a mutual or cooperative although organized as a stock company. The company is also engaged in electrical power distribution (purchased wholesale from Bonneville Power Administration) within the same area as its water distribution.

WWP is the region's primary generator and distributor of electrical power. WWP is also the largest stockholder owned water purveyor when the aggregate population served in ten separate service areas is considered. These ten service areas are widely scattered and highly variable in size and service population. The location and service population of these ten service areas are as follows:

No.	No.	Served	Name	Location
1	93350	3872	West Spokane Valley	Abuts East City Boundary
2	93351	4737	South Spokane Valley	Four separate areas south of Opportunity
3A	93353	3824	North Spokane	Abuts North City Boundary
3B	93354	1205	Mead	Mead and N.W. of Mead
3BP	93355	475	Pine River	North of Mead

3C	93356	223	Riverview Hills	North of Colbert
3D	93357	213	Chattaroy Hills	West of Little Spokane River at Chattaroy
4	93358	511	South Spokane	Abuts South City Boundary
6	93360	9	Waterview Terrace	On Long Lake
21	13450	207	Clayton	4 miles N.W. of Deer Park

Water Associations and Cooperatives. Of the seven systems in this category, six serve populations of 100 and less. Only the Liberty Lake Improvement Club system is of significant size with a service population of 300. All except Glenrose (DSHS 28135) and Liberty Lake improvement Club (DSHS 47145) are at isolated locations. Glenrose is near the southeast corner of the City. Four of the seven are in the Columbia plateau areas and draw their supplies from the basalt aquifer.

Other Systems. The most important of the systems in categories other than considered above is that of Fairchild AFB, located approximately 8 miles west of the City on the Columbia plateau. This is the third largest water system in the study area considering population served in a single contiguous area, being exceeded only by the City and Modern Electric Water Company. The Fairchild AFB service population is approximately 6000 persons. This system, although eight miles from the nearest point on the primary aquifer, takes the larger part of its supply from there. Three wells with total pump capacity 4900 gpm are located in the SV aquifer near the Spokane River. A single well with 800 gpm pumping capacity is located in the basalt aquifer.

Domestic Water Use and Sources

The average daily demand on an annual basis is summarized for individual systems in Table 14-2, along with service population, number of services and an indication of the water source by aquifer and number of wells. Table 14-3 aggregates average daily water use, population and number of services by system categories and expands the use data to include peak day demand, maximum 7-day demand, total annual use and average annual per capita use.

The outstanding characteristics of urban and suburban water use in the study area are the high overall average per capita use, the fact that most of the high rate of use is associated with landscape or domestic pasture irrigation and the high variability in use from system to system. The study area annual average rate of water use is 279 gallons per capita per day. For the City service area, which has the highest proportion for domestic use as opposed to landscape irrigation use, the

TABLE 14-3

DOMESTIC WATER USE SUMMARY

Agency Type	Population	No. of Services	Avg. Daily Demand/MGD	Peak Day Demand/MGD	Max. 7-Day Demand/MG	Total Annual Demand/MG	Average Per Capita Demand/GPCD	No. of Wells
Municipal	191,789	59,201	53.43	150.00	858.60	19,501	279	42
Irrigation Districts	35,942	10,262	20.31	52.79	309.60	7,412	565	63
Water Districts	14,168	4,082	1.71	13.28	76.14	624	121	18
Private Co's.	31,846	9,213	6.27	36.69	209.90	2,289	197	43
Assn's-Coops	517	172	0.20	0.39	2.28	73	387	9
Developments[1]	1,745	577	0.23	0.54	3.09	84	132	25
Residential Totals[2]	276,007	83,507	82.15	253.70	1460.00	29,983	298	200
Federal[3]	15,147	2,057	2.02	7.30	41.80	737	133	6
State[3]	10,540	35	1.58	2.25	12.89	577	150	4
Spokane Int. Airport	2,250	26	0.46	0.65	3.50	168	204	2
Other[4]	5,900	-	0.16	0.45	2.38	58	27	52
TOTAL	309,844	85,625	86.37	264.30	1520.00	31,523	279	264

[1]Includes Mobile Homes.
[2]Considers only the first six Agency Types.
[3]Does not include Campgrounds.
[4]Includes Motels, Trailer Parks, Schools, Resorts & Campgrounds.

proportions are 63 percent domestic and 37 percent irrigation. The average use in the urban area ranges from 85 gpcd in East Spokane Water District #1 to 822 gpcd in Pasadena Park ID #17.

Except for the communities west of the City which are located on Columbia plateau formations, the entire domestic water supply of the urban and suburban areas of Spokane derive their water supply from the SV aquifer. The basalt aquifer of the Columbia plateau has proven to be an inadequate source for the relatively small communities located on its surface. Fairchild AFB, located on the Columbia plateau, is the only exception, having gone to the SV aquifer to augment their local supply.

Current Planning for Domestic Supply

The City, with a well developed utilities department, has a planning program to match requirements for projected City growth. These plans are essentially internal and do not involve other new supplies, so they are not of significance to this study.

Outside the City, the most significant concurrent planning effort for water supply is related to the area west of the City, cited above as

having an inadequate supply. The planning effort includes a study made by Black and Veatch, Consulting Engineers, in 1973 for Spokane County titled "Interim Report on Spokane Plains Water Supply." This report covers an area which includes the communities of Airways Heights, Medical Lake, Fairchild AFB, Four Lakes, Cheney, Four Corner and Spokane International Airport plus the adjoining rural areas. Alternative supplies all rely on importation of SV aquifer water, the primary variations being whether it would be supplied through arrangement with the existing City system or by an independent system. A plan with a 1975 project cost of $8,800,000 is suggested to supply 18 mgd (1975) to 27 mgd (2000).

As of the fall of 1975, Spokane County has retained Black and Veatch for further services leading toward implementation of a program to augment water supplies in the City service area.

Industrial Water Use

All of the major industries in the study area are located in or near the City. The water supplies for these industries are derived from two principal sources, the domestic water system of the area in which they are located or a private system belonging to the industry, or to a combination of both.

Thirty-nine major industries with significant water use are identified and listed in Table 14-4 along with their sources of water supply and average and peak monthly water consumption. Other industrial users not here listed have their water use included in the overall domestic water use of the area in which they are located. These other industries have not been identified as having any significant process water use. Major hospitals are not included herein as an industry; their use being left in the overall domestic use.

Three industries use over 100 million gallons per month each, namely Inland Empire Paper and two Kaiser plants. These three plants account for approximately 66 percent of the total industrial use excluding the Kaiser Trentwood cooling water supply. The Kaiser Trentwood cooling water supply deserves special mention since it is so large and is of unique character compared with other industrial use. For this reason it has been treated as a special category herein and, in general, is not included with other industrial use in the tables and analyses. The characteristics which make the Kaiser Trentwood cooling system unique are (1) it is drawn from the Spokane River whereas all other industrial supplies are taken from groundwater and (2) it is returned after use directly to the Spokane River immediately downstream from its point of withdrawal. The volume of this cooling water flow is 532 million gallons per month or about 80 percent of all other industrial use combined. Tables 14-4 and 14-5 do not include this flow nor is it considered in the following summary paragraph.

TABLE 14-4

INDUSTRIAL WATER SYSTEMS

Industry	Industry Type	Water Sources	Monthly Water Use Millions of Gallons Average	Peak
Alladin Metalcraft	Plating	C	0.18	0.24
Alsco Linen	Laundry	C,P	1.52	1.80
American Bumper Service	Plating	C	0.01	0.01
American Sign & Indicator	Mfg-Display Signs	C,P	0.19	0.22
Arden Farms	Dairy Distributor	C	1.00	2.17
Becwar Meat Packing	Meat Packing	C	1.59	2.33
Bonanza Meat Packing	Meat Packing	C	2.76	4.97
Burlington Northern	Railroad	C,P	21.60	26.90
Carnation Co.	Dairy	C	0.86	2.41
Centennial Mills(Sprague)	Gluten & Starch	C,P	14.62	16.72
Centennial Mills(Trent)	Wheat Flour	C,P	0.61	0.76
Central Heating	Heating Plant	C	7.36	11.91
Central Premix	Sand & Gravel	C,P	17.00	28.30
Coca Cola Bottling	Soft Drink Bottling	C	0.80	1.08
Crescent (Downtown)	Department Store	C	16.48	37.10
Crystal Linen	Laundry	C,P	1.66	1.91
Culligan Soft Water	Water Softening	C	0.83	0.97
Darigold	Dairy	C	20.00	28.50
Hillyard Proc.(Sullivan)	Aluminum Processing	P	16.07	21.55
Hillyard Proc.(Wellesley)	Aluminum Processing	P	0.01	0.01
Hollister-Stier	Pharmaceuticals	C	1.25	2.85
Hygrade Foods	Meat Packing	C,P	14.08	21.81
Ideal Laundry	Laundry	C	-	-
Inland Empire Paper	Paper Mill	CM,P	103.70	121.60
Inland Empire Plating	Plating	C	1.16	1.55
ITT Bakery	Bakery	C	1.00	1.44
Kaiser(Mead)	Aluminum Prod.	P	136.90	206.40
Kaiser(So. Mead) & R. A. Hanson	Coke Prod. & Equip. Mfg.	P	9.49	11.60
Kaiser(Trentwood)	Aluminum Fabrication	P,R	197.80	236.67
Linde-Union Carbide	Acetylene Prod.	C	0.49	1.37
Metallic Arts	Plating	C	0.18	0.24
Nalley's	Potato Chip Prod.	C	2.43	3.94
Seven-Up Bottling	Soft Drink Bottling	C	2.01	3.10
Spokane Industrial Park	Industrial Park	P	57.83	86.75
Spokane Rendering	Rendering Plant	P	3.89	5.42
Spokesman-Review	Newspaper Pub.	C	4.10	4.67
Troy Laundry	Laundry	C,P	0.61	0.68
Union Pacific	Railroad	C	5.55	17.30
Victory Plating	Plating	C	0.03	0.04
Industrial Use			667.65	917.29
Kaiser Trentwood Cooling		R	532.22	584.57
TOTAL INDUSTRIAL USE			1199.87	1501.86

C = City of Spokane, CM = City of Millwood, P = Private Well(s), R = Spokane River.

TABLE 14-5

INDUSTRIAL WATER SOURCES OTHER THAN MUNICIPAL SYSTEMS

Industry	Source: Groundwater No. of Wells	Source: Surface Water	Annual Withdrawal Millions of Gallons	Pump Capacity GPM
Alsco Linen	1		16.4	120
American Sign	1		2.0	32
Burlington Northern	3		216.0	1,490
Centennial (Sprague)	1		56.3	110
Centennial (Trent)	1		1.4	-
Central Pre-Mix	4		204.0	650
Crystal Linen	1		19.7	250
Hillyard (Sullivan)	1		193.0	450
Hillyard (Wellesley)	1		0.12	150
Hygrade	1		144.0	385
Inland Empire Paper	4		1,244.0	8,500
Kaiser (Mead)	3		1,643.0	-
Kaiser (So. Mead) & R.A. Hanson	-		114.0	-
Kaiser (Trentwood)	1		1.5	3,900
Spokane Cold Storage	1		-	-
Spokane Industrial Park	3		694.0	3,150
Spokane Rendering	1		45.5	450
Troy Laundry	1		5.4	-
SUBTOTAL FROM WELLS			4,600.0	-
Kaiser Trentwood		Spokane R.	8,759.0	
SUBTOTAL SURFACE WATER			8,759.0	
TOTAL			13,359.0	

Tables 14-4 indicates the source of each industrial supply. The total monthly use is 668 million gallons or 8016 million gallons per year. This is equal to approximately 25 percent of the total domestic water use of the study area. Of this 668 million gallon per month total, 285 million gallons or 43 percent are from municipal systems and 383 million gallons or 57 percent are from private industrial sources. All of the supply, both municipal and private industrial, are from groundwater drawn from the primary SV aquifer. Table 14-5 lists the industries with private supplies, the number of wells, pump capacity and annual use.

Recycle and Recycle Potential

One of the reasons for investigating industrial water use in detail is to determine its potential relationship to wastewater management through recycle. The following paragraphs report the findings on existing recycle practice and the potential for recycle if reclaimed waters were made available.

Twenty-nine of the largest industries were canvassed to determine recycle activity and potential. The objectives addressed are as follows:

1. Determine to what extent water is presently being used more than once either by

   a. Using the untreated waste from one process recirculated
      (1) Through the same process
      (2) Through another process

   b. Using treated waste from one process recirculated
      (1) Through the same process
      (2) Through another process

2. Determine to what extent wastewaters are being produced that are substantially of a quality that could be reused with little or no treatment or with a simple type of treatment.

3. Determine what processes could use water of less than optimum quality that might be available as an untreated or economically treated waste.

The conclusions reached from this survey are as follows:

1. At present, industrial recycling is negligible in quantity except for the Inland Empire Paper Company recirculation of process water which is motivated by product recovery. In general, water is so available and inexpensive that there is little if any economic incentive for recycling.

2. There is a significant use of water for cooling which produces a waste that is substantially unmodified chemically and pollutionally except for temperature increase. These waters should not be regarded without qualification to be free of pollution since there is always pollution potential from leaks in the heat exchanger equipment. Hence, its consideration for reuse should be qualified by that limitation. For example, it could not be used as wash water for a food product. The total use of "once through" cooling water is approximately 6.3 mgd average (exclusive of the Kaiser Trentwood cooling flow which is returned to the river with other treated wastes).

3. There are waste flows other than cooling water with quality characteristics that have potential for reuse but the total quantity is insignificant on a study area-wide basis. The potential of these other flows is substantially limited to "in-house" recycling. The total of these flows is less than 1.5 mgd.

4. The industrial uses which could use reclaimed water in significant quantities are limited to three industries with an aggregate demand of 1.5 mgd. Cooling water is not listed for potential reuse in this sense.

The future prospects for recycle opportunities for reclaimed wastewaters are no more hopeful than the present conditions since the forecast pattern of growth is away from heavy primary industry toward service industries with little water use or toward food processing which requires waters of the very highest quality.

At present most industrial wastewaters are disposed of by either the City sewage collection system or a private disposal system. Once mixed with sanitary sewage the recovery and recycle problem becomes part of the larger problem for the area's sanitary sewage. The loss in potential reuse is significant only for unpolluted cooling waters.

Agricultural Irrigation

Four sources of data are evaluated and interpreted to form the basis for the estimation of irrigated agricultural acreage and water use. None of the sources or combinations of sources provide sufficient reliable data to remove the conclusions reached from the qualification of "estimate."

The four sources evaluated are:

1. U.S. Department of Commerce, Bureau of the Census: <u>1969 Census of Agriculture</u>.

2. U.S. Department of Agriculture, Soil Conservation Service. <u>Washington Soil and Water Conservation Needs Inventory</u>, 1970.

3. Department of Ecology: Water Rights Files.

4. Records of Irrigation Districts supplemented by interviews with District management.

The primary conclusion from evaluation of these sources is that there is an unmet need for a reliable method of determining the quantity of water being used for agricultural irrigation in the study area.

In order to arrive at some measure of the total agricultural use, the sources are combined to first make an estimate of irrigated areas as shown in Table 14-6 and then convert these findings to average annual use by mean application factors as shown in Table 14-7. The annual pattern of use is determined from Consolidated Irrigation District records, which applied to the study area as a whole, indicates the monthly pattern of use shown in Table 14-8.

The study area total annual use for agricultural irrigation is estimated at approximately 36,000 acre feet. For Spokane County alone, the estimate is 30,000 acre feet which is 23 percent higher than that given in the 1969 Census of Agriculture.

The irrigation season extends from April through October, but the significant quantities are used from May through September. The peak month is July for which the average use is 27 percent of the annual use. The peak month withdrawal rate from the area in WRIA 57 served by groundwater from the primary aquifer is equivalent to 98 cfs.

Non-agricultural Irrigation

Non-agricultural irrigation as referred to herein includes irrigation of parks, golf courses and highway landscaping. Landscape, home gardening and pasture irrigation by individual home owners is not included, having been included as a component of domestic water use.

Non-agricultural irrigation is supplied from two sources in the study area; from regular water systems and from separate wells specifically for this purpose. There are cases where both sources apply to a given location.

TABLE 14-6

ESTIMATION OF ACTUAL IRRIGATED LAND
IN THE STUDY AREA (BASED ON ADJUSTMENT OF WATER RIGHTS DATA
TO MATCH CONTROL TOTAL FROM 1969 CENSUS OF AGRICULTURE)

	Irrigated Areas, Acres														
	Water Resource Inventory Areas												Study Area Total		
	54			55			56			57					
County	G.W.[1]	S.W.[1]	Tot.[1]	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.
Spokane I.D.	-	-	-	0	-	0	-	-	-	5,100	-	5,100	5,100	-	5,100
w/o I.D.[2]	2,142	135	2,277	3,183	2,166	5,349	972	870	1,842	2,103	701	2,804	8,400	3,872	12,272
Total	2,142	135	2,277	3,183	2,166	5,349	972	870	1,842	7,203	701	7,904	13,500	3,872	17,372
Lincoln[3]	543	373	916	-	-	-	-	-	-	-	-	-	543	373	916
Pend Oreille[3]	-	-	-	624	474	1,098	-	-	-	-	166	166	624	640	1,264
Stevens[3]	1,056	599	1,655	556	179	735	-	-	-	-	-	-	1,612	778	2,390
Whitman	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3,741	1,107	4,848	4,363	2,819	7,182	972	870	1,842	7,203	867	8,070	16,279	5,663	21,942

[1]G.W. = Ground Water Source, S.W. = Surface Water Source, Tot. = Total G.W. and S.W.
[2]For Spokane County without Irrigation District claims, adjusted by factor 0.4835.
[3]For Counties other than Spokane, adjusted by factor 0.50.

TABLE 14-7

ESTIMATION OF ANNUAL WATER USE FOR AGRICULTURAL IRRIGATION

	Annual Water Use, Acre-Feet														
	Water Resource Inventory Areas												Study Area Total		
	54			55			56			57					
County	G.W.[1]	S.W.[1]	Tot.[1]	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.
Spokane I.D.[2]	-	-	-	0	- -	0	-	-	-	15,300[5]	-	15,300	15,300	-	15,300
w/o I.D.[2]	1,714	108	1,822	2,546	1,733	4,279	778	696	1,474	6,309[5]	561	6,870	11,347	3,098	14,445
Total	1,714	108	1,822	2,546	1,733	4,279	788	696	1,474	21,609	561	22,170	26,647	3,098	29,745
Lincoln[3]	858	589	1,447	-	-	-	-	-	-	-	-	-	858	589	1,447
Pend Oreille[4]	-	-	-	655	498	1,153	-	-	-	-	174	174	655	672	1,327
Stevens[6]	1,521	863	2,384	801	258	1,059	-	-	-	-	-	-	2,322	1,121	3,443
Whitman	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4,093	1,560	5,653	4,002	2,489	6,491	778	696	1,474	21,609	735	22,344	30,482	5,480	35,962

[1]G.W. = Ground Water Source, S.W. = Surface Water Source, Tot. = Total G.W. and S.W.
[2]Based on 0.80 ft/yr.
[3]Based on 1,58 ft/yr.
[4]Based on 1.05 ft/yr.
[5]Based on 3.00 ft/yr.
[6]Based on 1.44 ft/yr.

TABLE 14-8

SEASONAL PATTERN OF WATER USE FOR AGRICULTURAL IRRIGATION IN THE STUDY AREA

Month	Water Use, Acre Feet		
	Ground Water	Surface Water	Total
January	-	-	-
February	-	-	-
March	-	-	-
April	806	145	951
May	5,052	908	5,960
June	6,004	1,079	7,083
July	8,350	1,501	9,851
August	5,997	1,078	7,075
September	3,854	693	4,547
October	418	75	493
November	-	-	-
December	-	-	-
Total	30,481	5,479	35,960

Total non-agricultural irrigation is found to be a relatively small use, totaling approximately 4000 acre feet annually, of which golf courses and city parks account for 2300 and 1400 acre feet respectively.

Summary of Present Use

Annual water use for the study area for each of the four major categories of use is summarized in Table 14-9. The totals are developed for groundwater and surface water sources separately and combined. For all categories of use, the groundwater source is predominant and, overall, represents 92 percent of consumptive use.

So-called domestic use is by far the largest category of use at 60.9 percent, followed by agricultural irrigation and industrial use, at 22.6 percent and 15.5 percent respectively. Non-agricultural irrigation, not otherwise accounted for under domestic use, is of small significance.

Irrigation of home landscaping, gardens and pasture is not precisely measurable but can be estimated from the annual use pattern. The estimated use for domestic irrigation determined on this basis is 15,000

TABLE 14-9

ANNUAL WATER USE
STUDY AREA SUMMARY, 1972

Use Category	ANNUAL WATER USE								
	Billion Gallons			Acre Feet			Percent of Total		
	G.W.[1]	S.W.[1]	Tot.[1]	G.W.	S.W.	Tot.	G.W.	S.W.	Tot.
Domestic	31.52	-	31.52	96,740	-	96,740	60.9	-	60.9
Industrial[2]	5.64	2.37	8.01	17,310	7,270	24,580	10.9	4.6	15.5
Agricultural	9.93	1.79	11.72	30,480	5,480	35,960	19.2	3.4	22.6
Non-Agricultural Irrigation	0.52	-	0.52	1,600	-	1,600	1.0	-	1.0
TOTAL	47.61	4.16	51.77	146,130	12,750	158,880	92.0	8.0	100.0

[1]G.W. = Ground Water Source, S.W. = Surface Water Source, Tot. = Total G.W. and S.W.
[2]Not including Kaiser Trentwood's non-consumptive cooling water use.

million gallons per year or approximately 50 percent of the total domestic use. For suburban areas considered alone, the irrigation use is as high as 75 percent of the total annual use.

Strictly domestic (that is, indoor) use is therefore about 30.4 percent of total study area use, as is also the domestic irrigation component. These components individually are approximately 35 percent larger than agricultural irrigation and one hundred percent more than industrial use. The strictly domestic component of per capita use at 139 gpcd for the study area as a whole is high compared with national averages. The unusually high domestic indoor and outdoor uses appear to be the consequences of the abundance and relative low cost of water in the study area.

A further breakdown of use by source is shown in Table 14-10. This shows that the primary aquifer provides 88.5 percent of the groundwater supply and that 3.2 percent and 8.3 percent are supplied by the Little Spokane Valley and the aquifers respectively.

Table 14-10 shows that the only significant surface water withdrawal from the Spokane River is for industrial purposes, amounting to only 2372 million gallons annually of consumptive use and 6387 million gallons annually for the Kaiser Trentwood cooling water diversion. The consumptive use is equal to an average flow of 10 cfs and the Kaiser Trentwood diversion to 27 cfs. For comparison, the mean annual flow of the Spokane River at Spokane is 6927 cfs.

By comparison to the available flow, the surface water use from the Little Spokane River is proportionately more significant. Table 14-10 shows that the predominant use of surface water from the Little Spokane

TABLE 14-10

ANNUAL WATER UTILIZATION BY SOURCE

Use Category	Water Use, Million Gallons[1] Surface Water: Spokane River	Surface Water: Little Spokane & Trib.	Surface Water: Other Sources	Ground Water: Primary Aquifer	Ground Water: Little Spokane Valley	Ground Water: Other (Basalt) Aquifers	Totals: Ground Water	Totals: Surface Water	Totals: Total
Domestic	-	4.1	-	29,271	230	2,018	31,519	4.1	31,523
Industrial	2,372	-	-	5,640	-	-	5,640	2,372	8,012
Agriculture	-	811	975	7,041	1,304	1,587	9,932	1,786	11,718
Non-Agricultural Irrigation	-	-	-	186	7.6	329	523	-	523
TOTAL	2,372	815	975	42,138	1,542	3,934	47,614	4,162	51,776

[1]Does not include Kaiser Trentwood's non-consumptive cooling water use.

is agricultural irrigation and amounts to 2489 acre feet annually, equal to an average of 3.4 cfs. For the peak month in the irrigation season, this diversion is estimated to be 11.3 cfs. For comparison, the Little Spokane River has a mean annual flow of 665 cfs, and a minimum flow of 63 cfs at the Dartford gage.

The synthesized annual pattern of water use for all categories is shown in Table 14-11. This shows that the peak use in July is equal to 18.4 percent of the total average annual use. For groundwater from all

TABLE 14-11

MONTHLY WATER USE - STUDY AREA SUMMARY, 1972

Month	Domestic G.W.[2]	Domestic S.W.[2]	Domestic Tot.[2]	Industrial[1] G.W.	Industrial[1] S.W.	Industrial[1] Tot.	Agricultural G.W.	Agricultural S.W.	Agricultural Tot.	Non-Agricultural Irrigation G.W.	Non-Agricultural Irrigation S.W.	Non-Agricultural Irrigation Tot.	Total G.W.	Total S.W.	Total Tot.
January	1,465	-[3]	1,465	467	196	663	-	-	-	-	-	-	1,932	196	2,128
February	1,396	-	1,396	383	161	544	-	-	-	-	-	-	1,779	161	1,940
March	1,513	-	1,513	404	170	574	-	-	-	-	-	-	1,917	170	2,087
April	1,747	-	1,747	443	186	629	263	47	310	7	-	7	2,460	233	2,693
May	2,932	-	2,932	506	213	719	1,646	296	1,942	26	-	26	5,110	509	5,619
June	3,613	-	3,613	540	227	767	1,956	352	2,308	91	-	91	6,200	579	6,779
July	5,525	-	5,525	500	210	710	2,721	489	3,210	101	-	101	8,847	699	9,546
August	5,163	-	5,163	581	244	825	1,954	351	2,305	243	-	243	7,941	595	8,536
September	3,177	-	3,177	545	229	774	1,256	226	1,482	46	-	46	5,024	455	5,479
October	1,895	-	1,895	448	189	637	136	24	160	8	-	8	2,487	213	2,700
November	1,494	-	1,494	456	192	648	-	-	-	-	-	-	1,950	192	2,142
December	1,602	-	1,602	367	155	522	-	-	-	-	-	-	1,969	155	2,124
Year Total	31,522	- -	31,522	5,640	2,372	8,012	9,932	1,785	11,717	522	-	522	47,616	4,157	51,773

Monthly Water Use, Million Gallons[1]

[1]Does not include Kaiser Trentwood's non-consumptive cooling water use.
[2]G.W. = Ground Water, S.W. = Surface Water, Tot. = Total G.W. and S.W.
[3]Indicates essentially zero.

aquifers, the July use is 8847 million gallons and for the primary aquifer is 7753 million gallons. The peak month withdrawal rate for the primary aquifer is equal to a rate of 394 cfs. This is a significant proportion of the estimated 1000 cfs flow of groundwater entering the study area at the State line.

Forecast Water Use

Scope. Forecasts of water use are developed for three categories, municipal, industrial and agricultural, for both the urban and non-urban planning areas 1980 to 2000. These forecasts are based on forecasts of population and economic activity and on evaluated trends in water use. These forecasts are a prerequisite element of the wastewater forecast discussed above.

Municipal Use. The general method used in forecasting municipal use is based on the evaluation and trending of present per capita use. Factors which are reflected in the present levels of water use are the type of residential development, lot size, soil characteristics, water rates, presence of commercial development, the socio-economic character of the neighborhood and the availability of water. Forecast trends in water use are selected to reflect anticipated changes in these factors. Also overall consideration is given to national trends which are toward reduced rate in growth of water use and concern for conservation of this resource. Increasing costs of water and wastewater treatment are also expected to exert pressure against continued high growth in rate of use.

Evaluations of forecast per capita use are made on small units of area due to the wide range of present use throughout the study area, except that the City is treated as a whole. The resultant forecast per capita use and trend therefore varies widely. Only a small increase in per capita use is forecast for the City, from the present 290 gpcd to 304 gpcd at year 2000. Certain areas in Spokane Valley are forecast to show a moderate increase, due mainly to an evaluated increase in commercial and small industrial components. Similar variations result from detailed consideration of areas in North Spokane. The forecast total use is the product of the forecast per capita demands and the forecast population.

Industrial Use. The industrial water use forecast is based on the forecast employment in large industry as previously discussed under wastewater flow forecasts. The amount of water intake by industries that does not appear in the wastewater flows due to being converted to water vapor or being incorporated in the product is negligible. Therefore, the water use and wastewater flows are substantially equal.

The Kaiser Trentwood cooling water diversion from the Spokane River, which presently averages 17.5 mgd, is set out separately from the rest of the industrial use in the Spokane Valley. This large use is the only significant surface water use in the urban planning area, all other being supplied from groundwater. It is assumed that this use will remain unchanged throughout the study period based on Kaiser's statement that there are no plans for change.

Agricultural Water Use in the Urban Planning Area. Substantially all of the commercial irrigated agriculture in the urban planning area is in the Spokane Valley. At present approximately 7900 acres out of the 25,500 acres devoted to agriculture in the Spokane Valley are under irrigation. Approximately 5100 acres are served by irrigation districts and the remainder by private sources. The forecast land use data indicate that urban development will reduce the total acreage devoted to agriculture to 22,200 acres by 2020. The present proportion of irrigated land is 31 percent. It is estimated that as the amount available for agriculture is reduced there will be pressure for increased production and crop value provided by irrigation. This is recognized by selection of 40 percent as the irrigated portion in 2020, bringing the total irrigated acreage to 8900, about 1000 acres more than at present. The present average application rate for the Spokane Valley, at 2.8 feet per year, is assumed to apply throughout the study period.

Agricultural Water Use in the Non-Urban Area. The forecast agricultural water use outside the urban planning area is considered in elements corresponding to WRIA similar to the evaluation of present use.

- WRIA 54 Lower Spokane

The Lincoln and Spokane County portions of this area are predominantly dry farmed and the available water supply is very limited. Without import of water, the irrigated area in these counties in WRIA 54 is assumed to remain unchanged. There is some potential water supply in the Chamokane River Valley for increased irrigation in the Stevens County portion. A 10 percent increase to the year 2020 is selected based on available water but limited suitable land.

- WRIA 55 Little Spokane

The general agriculture in this area is oriented toward pasture and similar activities in support of dairies and cattle. There is already a significant amount of irrigated agricultural land. The utilization of surface waters appears to have reached its limit in the present DOE moratorium on further surface water rights on the Little Spokane. However, there should be some remaining groundwater potential which, with present trends in food need, will probably be utilized to further increase irrigation in this basin. A 10 percent increase to 2020 is forecast.

- WRIA 56 Hangman Creek

This is predominantly dry farmed Palouse country with no surface water supply and very limited groundwater. It is assumed that irrigation level will remain unchanged.

- WRIA 57 Upper Spokane

There is both little suitable land and no available surplus water in the areas outside the Spokane Valley. No change in irrigation is forecast outside the urban planning area.

Summary, Water Use in the Urban Planning Area. The results of the projected urban planning area water use are shown in Table 14-12. Here, annual water demands are shown for each major planning unit, broken down into domestic-commercial, industrial and agricultural uses. The changes in the total water usages by categories are calculated below:

Use Category	Percent Change from 1970 to 2020
Domestic	+60
Industrial[1/]	+37
Agricultural	+12
Total[1/]	+46

The continued growth of urbanization and municipal water use as compared with industry and agriculture is apparent in the foregoing and also below in the shift in the share of total use.

Use Category	Percent of Use 1970	2020
Domestic	58.0	63.2
Industrial[1/]	27.2	25.4
Agricultural	4.8	1.4
Total[1/]	100.0	100.0

Summary, Water Use in Non-Urban Areas. Table 14-13 presents a summary of the forecast of water use outside the urban planning area.

[1/] Excluding Kaiser Trentwood's non-consumptive cooling water use.

TABLE 14-12

SUMMARY, PROJECTED WATER USE
URBAN PLANNING AREA

Unit	Use	Annual Water Use - Millions of Gallons						
		1970	1980	1985	1990	1995	2000	2020
City[1]	Municipal[2]	18,418	20,057	20,491	21,024	21,502	21,995	23,572
	Industrial	1,278	1,427	1,555	1,694	1,851	1,934	2,172
	Agricultural	-	-	-	-	-	-	-
	Subtotal	19,696	21,484	22,046	22,718	23,353	23,929	25,744
Spokane Valley	Municipal[2]	7,497	9,450	10,132	10,837	11,498	12,151	14,290
	Industrial[3]	10,443	10,720	11,122	11,538	11,965	12,384	13,527
	Agricultural	7,215	7,528	7,678	7,769	7,851	7,710	8,107
	Subtotal	25,155	27,698	28,932	30,144	31,314	32,245	35,924
North Spokane	Municipal[2]	1,307	1,869	2,354	2,873	3,424	4,008	5,887
	Industrial	1,363	1,455	1,527	1,651	1,755	1,903	2,223
	Agricultural	-	-	-	-	-	-	-
	Subtotal	2,670	3,324	3,881	4,524	5,179	5,911	8,110
Orchard Prairie	Municipal[2]	26	36	36	40	40	44	51
	Industrial	2	2	3	3	4	5	6
	Agricultural	-	-	-	-	-	-	-
	Subtotal	28	38	39	43	44	49	57
West Plateau	Municipal[2]	106	106	131	157	186	219	354
	Industrial	104	105	105	105	105	105	106
	Agricultural	-	-	-	-	-	-	-
	Subtotal	210	211	236	262	291	324	460
Fairchild AFB	Municipal[2]	766	766	766	766	766	766	766
	Industrial	-	-	-	-	-	-	-
	Agricultural	-	-	-	-	-	-	-
	Subtotal	766	766	766	766	766	766	766
Total Urban Planning Area	Municipal[2]	28,120	32,284	33,910	35,697	37,416	39,183	44,920
	Industrial	13,190	13,709	14,312	14,991	15,680	16,331	18,034
	Agricultural	7,215	7,528	7,678	7,769	7,851	7,710	8,107
	Subtotal[3]	48,525	53,521	55,900	58,457	60,947	63,224	71,061
Kaiser Trentwood River Diversion	Industrial	6,388	6,388	6,388	6,388	6,388	6,388	6,388
Total Urban Planning Area	Municipal[2]	28,120	32,284	33,910	35,697	37,416	39,183	44,920
	Industrial	19,578	20,097	20,520	21,379	22,068	22,719	24,442
	Agricultural	7,215	7,528	7,678	7,769	7,851	7,710	8,107
	GRAND TOTAL[4]	54,913	59,909	62,288	64,845	67,335	69,612	77,449
Total as Acre Feet/Year		168,473	183,801	191,100	198,944	206,584	213,570	237,614
Total as Average mgd		151	165	172	179	186	192	213
Total as Average cfs		234	255	265	276	286	296	329

[1] Including Moran Prairie and Southwest Units.
[2] Including Commercial.
[3] Excluding Kaiser Trentwood's Non-Consumptive Cooling Water Use.
[4] Including Kaiser Trentwood's Non-Consumptive Cooling Water Use.

TABLE 14-13

SUMMARY OF FORECAST WATER USE
NON-URBAN PLANNING AREA

Unit	Use	Annual Water Use - Millions of Gallons						
		1970	1980	1985	1990	1995	2000	2020
WRIA 54	Municipal[1]	347	365	376	391	405	416	467
Lower Spokane	Industrial	201	201	234	234	241	241	252
	Agricultural	1,842	1,858	1,865	1,873	1,881	1,889	1,920
	Subtotal	2,390	2,424	2,475	2,498	2,527	2,546	2,639
WRIA 55	Municipal[1]	427	504	537	569	606	642	781
Little Spokane	Industrial	-	-	36	36	40	40	44
	Agricultural	2,115	2,158	2,179	2,200	2,221	2,242	2,327
	Subtotal	2,542	2,662	2,752	2,805	2,867	2,924	3,152
WRIA 56	Municipal[1]	964	1,161	1,263	1,372	1,493	1,635	2,270
Hangman Creek	Industrial			55	58	62	66	80
	Agricultural	480	480	480	480	480	480	480
	Subtotal	1,440	1,641	1,798	1,910	2,035	2,181	2,830
WRIA 57	Municipal[1]	135	172	186	204	226	245	321
Upper Spokane	Industrial			18	18	22	22	26
	Agricultural	57	57	57	57	57	57	57
	Subtotal	192	229	261	279	305	324	404
Total Non-Urban	Municipal[1]	1,873	2,202	2,362	2,536	2,730	2,938	3,839
Planning Area	Industrial	201	201	343	346	365	369	402
	Agricultural	4,494	4,553	4,581	4,610	4,635	4,668	4,784
	Grand Total	6,568	6,956	7,286	7,492	7,730	7,975	9,025
Total as Acre Feet/Year		20,151	21,341	22,353	22,985	23,728	24,467	27,689
Total as Average mgd		18	19	20	21	21	22	25
Total as Average cfs		28	30	31	32	33	34	38

[1] Including commercial.

Analysis of these results indicates the following trends.

Use Category	Percent Change from 1970 to 2020
Domestic	+105
Industrial	+100
Agricultural	+ 6
Total	+ 37

The domestic water use is increasing faster than the corresponding increase in the urban planning area, although the absolute increase is about one-tenth as much. The domestic use of water, although smaller than the agricultural use, is becoming more significant.

Use Category	Percent of Use 1970	2020
Domestic	28.5	42.5
Industrial	3.1	4.5
Agricultural	68.4	53.0
Total	100.0	100.0

This indicates that, although there are large percentage increases in municipal requirements, the remote areas are still predominantly agricultural with respect to water use.

Study Area Summary. The overall study area water demand forecast is shown in Table 14-14. It is forecast that by the year 2020, approximately 86 billion gallons of water (265,000 acre feet) will be used annually, a 40 percent increase from the 61 billion gallons used currently.

TABLE 14-14

SUMMARY OF FORECAST WATER USE
ENTIRE STUDY AREA

		Annual Water Use - Millions of Gallons						
Unit	Use	1970	1980	1985	1990	1995	2000	2020
Urban Planning Area[2]	Municipal[1]	28,120	32,284	33,910	35,697	37,416	39,183	44,420
	Industrial[2]	12,190	13,709	14,312	14,991	15,680	16,331	18,034
	Agricultural	7,215	7,528	7,678	7,769	7,851	7,710	8,107
	Subtotal	48,525	53,521	55,900	58,457	60,947	63,224	71,061
Non-Urban Planning Area	Municipal[1]	1,873	2,202	2,362	2,536	2,730	2,938	3,839
	Industrial	201	201	343	346	365	369	402
	Agricultural	4,494	4,553	4,581	4,610	4,635	4,668	4,784
	Subtotal	6,568	6,956	7,286	7,492	7,730	7,975	9,025
Study Area	Municipal[1]	29,993	34,486	36,272	38,233	40,146	42,121	48,759
	Industrial[2]	13,391	13,910	14,655	15,337	16,045	16,700	18,436
	Agricultural	11,709	12,081	12,259	12,379	12,486	12,378	12,891
	Total	55,093	60,477	63,186	65,949	68,677	71,199	80,086
Kaiser Trentwood River Diversion	Industrial	6,388	6,388	6,388	6,388	6,388	6,388	6,388
Study Area	Municipal[1]	29,993	34,486	36,272	36,233	40,146	42,121	48,759
	Industrial	19,779	20,298	21,043	21,725	22,433	23,088	24,824
	Agricultural	11,709	12,081	12,259	12,379	12,486	12,378	12,891
	GRAND TOTAL	61,481	66,865	69,574	72,337	75,065	77,587	86,474
Total as Acre Feet/Year		188,624	205,142	213,453	221,930	233,367	238,037	265,302
Total as Average mgd		169	184	192	199	207	214	238
Total as Average cfs		261	284	296	308	319	330	368

[1] Includes Commercial.
[2] Excludes Kaiser Trentwood's Non-Consumptive Cooling Water Use.
[3] Includes Kaiser Trentwood's Non-Consumptive Cooling Water Use.

Most of the present use and most of the future use will occur in the urban planning area. The domestic component is seen to be increasing faster than the other components for the entire study area. Agricultural water use shows the smallest increase. As expected, the urban planning area is forecast to consume most of the water used in the

study area. Currently, the urban planning area utilizes 88 percent of the study area's water needs and is forecast to utilize 89 percent by the year 2020. Over half of water demand for the study area, 45 billion gallons or 138,000 acre feet, is due to the domestic demand of the urban planning area.

Conclusions and Suggestions

1. The present total annual demand on the SV aquifer municipal, industrial and agricultural use is approximately 42 billion gallons or 129,000 acre feet annually. This is equal to an average withdrawal rate of 178 cfs or approximately 20 percent of the estimated flow entering from Idaho. The forecast use at year 2020 is approximately 46 percent greater or 260 cfs average withdrawal. The forecast withdrawal is 26 percent of the estimated annual renewal. Expressed in terms of average, the forecast requirements appear to be well within the capability of the source. The impact is to reduce the amount available for interchange with the Spokane and Little Spokane Rivers. If the entire increment of 82 cfs were to be at the expense of the interchange farthest downstream, it would reduce the augmentation of the lower Little Spokane River by 40 percent.

   Since these interchanges have such an important impact on quality, and temperature in particular, these forecast increases in withdrawal should be a matter of concern. The USGS simulation of the SV aquifer currently being developed would be an ideal tool to study this problem in conjunction with the surface water simulation developed by this study.

   The fact that the groundwater withdrawals are significantly higher in summer, estimated at 394 cfs at present in peak month, could aggravate the situation above what is apparent based on averages. Another consideration not covered is the concurrent construction of additional facilities for withdrawal by the Bureau of Reclamation in its East Greenacres[1/] project to irrigate 5340 acres. This project would add at least another 15 cfs average or 48 cfs in the peak summer months. Combined with the present peak withdrawal rates in the study area, this makes approximately 440 cfs total, approaching fifty percent of the average inflow.

   It is suggested that consideration be given to the fact that the SV aquifer has finite limitations and that an overall view considering both Idaho and Washington needs to be developed.

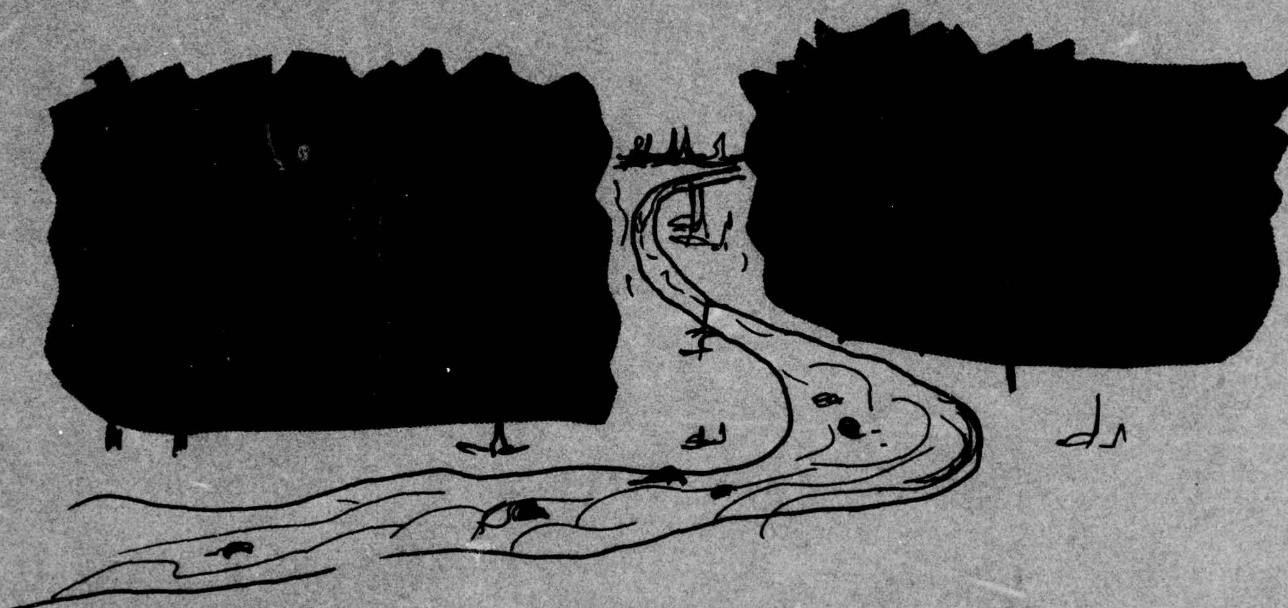
[1/] Located in Idaho outside the study area.

Other water quality implications that interchange with surface waters deserve consideration also as withdrawals increase. These would grow out of the reduced dilution and flushing which apparently are such an important factor in reducing the impact of percolate from on-site disposal in the Spokane Valley.

2. The quantities of water used in the Spokane Valley indicate over irrigation. This is also recognized by agricultural advisers. The extreme low cost of water does not encourage thrift in its use. On the other hand there is no economic need to raise rates and to raise them for control is unfair to those who do make prudent use of the supply. An educational program to keep water use in phase with need is required not only for Spokane Valley but throughout the urban area. The availability of a low cost water supply for landscape irrigation is one of the most important factors in the general quality of life in the Spokane Area. It is therefore important to maintain both the low cost and availability of the supply.

3. There are an unnecessarily large number of agencies in the business of purveying water. This provides neither optimum service nor optimum control. It is suggested that consideration be given to consolidation of agencies either as a separate County project or as an adjunct to the necessary institutional arrangements for implementation of wastewater management.

4. The records of water, particularly for agriculture, are inadequate. The DOE water rights file does not currently provide the tool necessary for control. The present condition of the DOE computer print-out of water rights data contains many errors and generally unusable data. The difficulties experienced by DOE in revising appropriations in the Little Spokane watershed emphasize the need for an improvement in records of actual water use.



SECTION 15

WATER QUALITY ENHANCEMENT AND FLOW AUGMENTATION

15. Water Quality Enhancement and Flow Augmentation

Introduction

A distinction is made here between water quality defects that are due to manmade pollution within the study area and water quality defects that are natural, created by non-pollutional construction or created by operations outside the study area. Correction of manmade pollution problems inside the study area are regarded as unmet needs for wastewater management. Improvement of undesirable natural conditions is regarded as an opportunity for quality enhancement. This section addresses the potential for improvement of natural conditions. These considerations are in most cases beyond the scope of this report and are speculative in nature. They do, however, represent conditions that should bear further investigation since the more accepted techniques do not answer all the problems.

Spokane River and Long Lake

Problems. The primary existing water quality defects of the Spokane River as it enters the study area are excessive coliform count and excessive temperature during the summer season. The excessive coliform counts are expected to be corrected with future enforcement of existing wastewater discharge standards. Water temperature conditions are the result of natural conditions rather than man's intervention and therefore are expected to continue indefinitely unless artificial means are taken to change them. There are two undesirable consequences of the high water temperature. One is that is makes the stream an unattractive environment to certain salmonid fish. The other is that the high water temperature contributes to the high rate of biological activity in Long Lake.

Excessively low summer stream flows in some summer seasons are undesirable for several reasons including loss of hydroelectric power productions, aesthetic and recreational losses and contribution to the seasonal eutrophication of Long Lake. The summer low flow is likewise a natural result and not the consequence of man's intervention. To some limited extent it could be alleviated by drawdown of stored volume in Coeur d'Alene Lake but this is not done because of its undesirable effect on power production and the use of the lakefront during the summer recreation season.

In Long Lake there is a strong stratification during the summer season due to the addition of warm river water to a reservoir filled with cold water at the beginning of the summer season. The lack of vertical circulation even with complete removal of point source pollutional loads will result in very low dissolved oxygen levels at depth. The lake is manmade and the method of withdrawal is a fixed feature of the dam and power generation equipment.

Alternatives. There are at least three ways in which lower temperatures could be induced in the Spokane River. One would require seasonal storage upstream from Coeur d'Alene Lake to provide higher summer flows which would result in lower heat gain from the ambient in the flowing sections in the river downstream from Post Falls. Another would be to induce outflow from a lower stratum in Coeur d'Alene Lake. A third would be to increase the volume of cold groundwater interchange. The first method is discussed below with regard to flow augmentation; in any case its effect would probably be minimal. Funk et al (1973) point out that "the discharge from Post Falls Dam had little secondary effect on temperatures. The controlling effect appeared to be direct solar radiation upon Coeur d'Alene River-Lake, and to some smaller extent upon the Spokane River."

With regard to drawing water from a lower level in Coeur d'Alene Lake, the physical feasibility is greatly reduced by the distance from Post Falls Dam to the lake outlet, which is nine miles. It would only be necessary to have a neutral bouyancy conduit for a fraction of the summer flow to reduce the total temperature, but the required structure would be large nevertheless: eight feet in diameter or more. The length and size of facility would appear to give this alternative low feasibility.

The groundwater interchange can be increased only by increasing the level of the SV water table which in turn can be accomplished by increasing the rate of recharge. There is available in the May-June runoff of the Spokane River large volumes of low temperature water that are not used beneficially in the study area. If a small portion of these excess flows could be induced into the SV aquifer for later discharge into the Spokane and Little Spokane Rivers, the benefits of lower temperature and summer stream augmentation could be realized. Typical excess water temperatures are about the same as groundwater temperatures, about 11°C. Therefore each cfs of groundwater would lower one cfs of surface water at its typical summer high of 22°C by 5°C.

There is a feasible area for recharge of the SV aquifer by Spokane River waters in the vicinity of the Idaho boundary. It has been estimated by the geological consultant that artificial recharge at the rate up to 10 cfs per acre, approximately 20 feet per day, is feasible. For a 160 acre site at a conservative 10 feet per day, the quantity that could be injected over a two-month period at the rate of 800 cfs would be 48,000 cfs days. A complex study would be

required to determine when this wave of injected water would reach the interchange area 6 to 8 miles downstream and the degree of attenuation. The indicated average rate of flow in the aquifer is approximately 60 feet per day or 88 days per mile, which would mean over a year to reach the interchange area of the river. The attenuation would undoubtedly be great so that the incremental interchange would probably not exceed 100 cfs. If this were the case, the temperature of a 1000 cfs river flow would only be lowered approximately 0.5°C more than it is now. For a 1000 cfs flow now, the lowering is approximately 2°C from the Idaho boundary to the east boundary of the City. This alternative offers a possible further reduction of 2.5°C total.

For the temperature potential alone this alternative does not offer sufficient incentive to seek implementation. In combination with flow benefits under forecast future withdrawals it may be worthwhile. Here again is a place where the USGS groundwater simulation model could be utilized to evaluate a possible future need.

Flow augmentation as an alternative for both the Spokane River and Long Lake in significant amounts is physically feasible only by storage on the tributaries to Coeur d'Alene Lake. The beneficial amount of flow augmentation is most critical with respect to the exchange rate through Long Lake. It would appear that for exchange rates of the order of once per month, the eutrophication problems become minimal even with the present levels of phosphorus loading. This is an approximation of the general finding by Soltero et al (1975) that retention time directly affected the trophic state of Long Lake. Soltero cites Dillon's modification of the work of Vollenweider in support of this finding. There are many qualifications and details of this finding that should be read in the referenced Soltero report. The selection of 28 days as a possible critical exchange rate is based on the observed conditions for years 1972, 1973 and 1974 in which the mean retention time in days was 38, 49 and 33 respectively. Long Lake was eutrophic in all three years but the range in condition was from highly eutrophic at nuisance levels in 1973 to a condition in 1974 that might be regarded as acceptable. Taking this level of flow as a measure of the desired need for flow augmentation, the problem is explored below.

Long Lake has a total volume of 254,570 acre feet at normal maximum pool of 1536 feet elevation, the elevation usually held through summer. The flow required for a 28 day exchange rate is to 4578 cfs. The calculated volume of storage required to be released from June through October to maintain a minimum flow of 4578 cfs rather than the historically experienced mean monthly flow is 279,000 acre feet. Refer to Table 2-2 for mean monthly flows. Considering the minimum monthly flows of record, the required volume could be a maximum of 747,000 acre feet. These figures can be compared with the storage potential of the last storage proposal on the tributaries to Coeur d'Alene Lake, namely the Enaville project. The Enaville project is not currently under consideration since at last evaluation it had an

unsatisfactory cost-benefit ratio. As proposed, the Enaville project would provide an active storage volume of 700,000 acre feet of which 300,000 acre feet are assigned to flood control which is not required to be available until 1 December. This project then would have the physical feasibility to provide the necessary level of flow augmentation. This then is another physically feasible method of impacting water quality and temperature control within the basin by external measures not related to wastewaters or pollution.

For power production reasons, Long Lake is maintained at a maximum pool level of 1536 feet throughout the summer season. The minimum operating pool level is 1512, five feet above the tops of the penstock inlets. At pool level 1512, the reservoir volume is reduced to 150,000 acre feet. To provide a 28 day exchange rate at this volume, the mean daily flow is correspondingly reduced to 2700 cfs. This flow closely matches the mean summer flow in August and September without augmentation. A 28 day displacement rate could be maintained over a significant part of the summer season in many water years. Lowering the summer pool level from 1536 to 1512 reduces the net head on the WWP power turbines by eight percent causing a corresponding eight percent loss in power generation capacity. This suggests a possible tradeoff, lost power generation versus phosphorus removal chemicals, if the level of biomass activity at pool level 1512 were acceptable without phosphorus removal. The approximate loss in power revenue July through December for a mean flow of 4061 cfs[1/], 80 percent water to wire efficiency and $.004 per kwh, is approximately $125,000. The cost for phosphorus removal chemicals for the July through 15 October period at 30 mgd flow is approximately $200,000. This appears to provide strong incentive for seeking to avoid phosphorus removal if acceptable conditions could be obtained at lowered pool.

Another measure that has been aired to impact water quality in Long Lake is alteration of the level at which water is drawn for release from Long Lake Dam. The present configuration of the outlet works provides penstock inlets approximately 30 feet below the surface at normal summer pool (pool 1536, top of penstock 1507, bottom of penstock 1491 feet elevation). The quality of the water, particularly its temperature below Long Lake Dam, indicates that the water being drawn off is almost entirely from the surface layer. It has been suggested that drawoff from the lower layers, in which nutrients are accumulating and oxygen levels are being depleted by stratification, would improve the trophic condition of the lake. A method of encouraging drawoff from a lower level would be to construct lower level penstock intakes. An hydraulic model study is a prerequisite to determine whether such construction would have the desired effect extending a significant distance from the dam followed by biochemical

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[1/] Plus 50,000 cfs days lost through drawdown of lake at a time when it cannot be used.

analysis to determine the subsequent effect on the biological activity. The possibility of a full scale trial at reasonable cost would appear to be possible through construction of heavy plastic film neutral bouyancy "awnings" over the penstock inlets and extending down to the desired level. The size of the awning would have to be sufficient to reduce dynamic forces due to approaching water to negligible levels.

The drawoff of lower level waters opens the possibility of creating undesirable water quality effects downstream that would not be worth the improvements upstream. It could well be that Long Lake is at present performing an important function in controlling eutrophic conditions in the Spokane River arm of Franklin D. Roosevelt Lake by acting as a nutrient trap during the critical summer season. Continuous release of the nutrient rich lower layers could create downstream problems.

Feasibility for Action on Alternatives. A number of unconventional alternatives for modification of Spokane River and Long Lake water quality have been suggested above. In summary they are:

1. Making summer withdrawals of Spokane River from a lower level in Coeur d'Alene Lake.

2. Creating storage upstream from Coeur d'Alene Lake to augment summer flows in the Spokane River and increase the Long Lake exchange rate.

3. Artificial recharging of the Spokane Valley aquifer to increase groundwater interchange with the Spokane River to lower temperature and augment flow.

4. Reducing summer pool level in Long Lake to increase effective exchange rate.

5. Creating low level drawoffs at Long Lake Dam to diminish the effects of stratification.

Item 1 and 2 appear to have little economic feasibility and are not suggested for any action. Item 3, although of doubtful value in lowering river temperature or raising river flow significantly, has significant added interest for its possible long range usefulness to augment the groundwater supply to meet forecast growth in use. For this reason it is suggested that the theoretical problems of artificial recharge be one of the items considered in the USGS modeling study of the hydraulic aspects of the aquifer.

Items 4 and 5 are, in effect, possible imperfect alternative solutions to a problem for which physical facilities are under construction for a more certain solution, whose main problem is going to be high operation costs extending indefinitely into the future. Having the

means to alleviate the eutrophication problem in Long Lake permits some experimental consideration of alternatives to possibly reduce the heavy operational costs. The simulation model has shown that seasonal phosphorus removal will probably have the same impact in reducing summer eutrophication as year-round removal. Alternatives 4 and 5 above are means by which further reduction might be sought in the phosphorus removal season and are suggested for further investigation. These alternatives, which have been characterized as an imperfect solution, bring into focus the question of how much the public is willing to pay for varying degrees of water quality improvement when that particular feature of improvement does not impact on public health. For example, if this type of solution could limit eutrophic activity to acceptable levels in say 7 out of 10 water years, would that be enough improvement for the price?

Little Spokane River

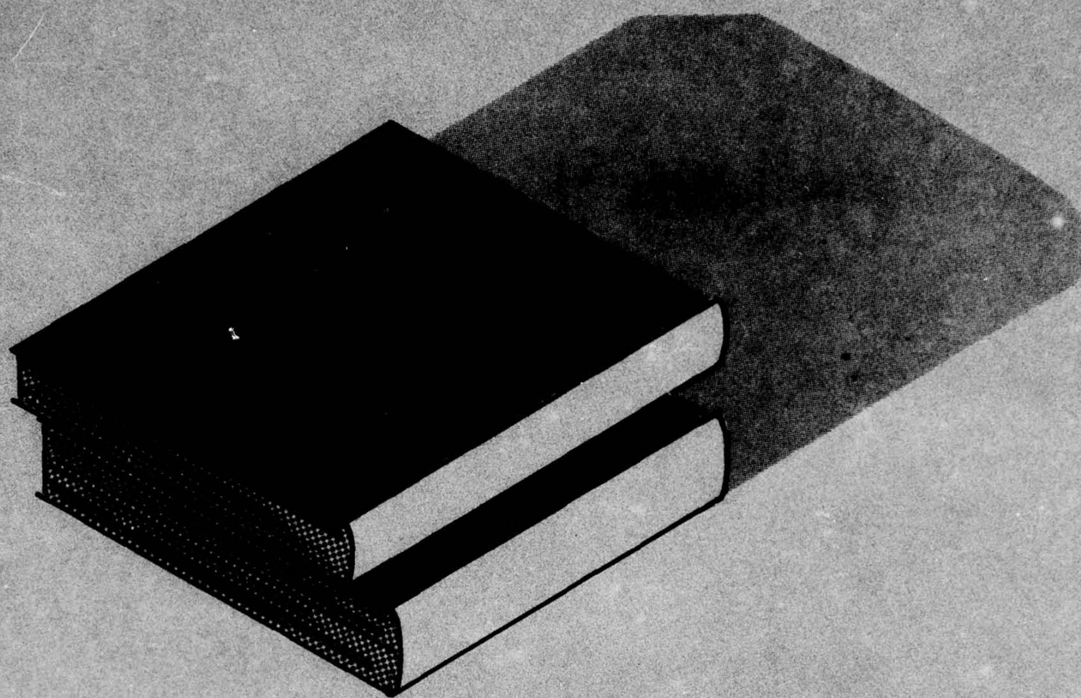
The Little Spokane River is a well behaved stream with a well sustained summer flow provided by nature. The only quality defects mentioned under evaluation as a fishery is the higher temperatures and loss of cover caused by removal of streamside trees throughout the agricultural areas. Here is an opportunity to artificially reverse a degradation of the environment by restoration of selected streams by protection of their banks from intensive use. An educational and tax incentive approach appear to be the only feasible means of implementation.

Hangman Creek

The primary defect of Hangman Creek is its flashy nature of high runoff and lack of significant sustained flow in the season without precipitation. Man's agricultural activity has increased the rate of runoff and added high rates of soil erosion to the problems.

The most serious water quality problem is the heavy silt load from erosion of the Palouse soils. The basic alternative is a non-structural one, namely revision of agricultural practices.

There appears to be little opportunity to control the flashy high flows or to sustain summer flows by structural means on Hangman Creek due to a lack of suitable sites for storage.



SECTION 16

THE DATA BASE

16. The Data Base

Introduction

An essential element of this study is the gathering and systemetizing of a data base. It is the function of this section to briefly describe the data gathering phase and, with the aid of the detailed listing in Appendix I in this report, provide a guide to the documentation of that data in the Appendices' Sections.

Aerial Mapping

Aerial photography of the entire study area and orthophoto mapping of the urban planning area was provided under subcontract with Aerial Mapping Service of Boise, Idaho. The photographic coverage consists of contact prints, 9 inches square at a scale of 1:24,000. The mapping consists of screened orthophotos on mylar at a scale of one inch equals 400 feet with contours at 10-feet interval.

A small portion of North Spokane had been covered by aerial mapping prepared for Spokane County in 1968 by Walker and Associates. The orthophoto mapping under this study did not duplicate these areas. Mylar copies of the County mapping were prepared at the same scale and in the same format as the orthophotos to provide complete one inch equals 400 feet mapping of the entire urban planning area.

Copies of the orthophoto mapping and of the aerial photographs are made available for purchase by local agencies through arrangements with the Corps of Engineers.

Other Study Area Mapping

A complete set of background maps for the entire study area as screened reproductions on mylar were prepared from USGS mapping to a uniform scale of 1:24,000. Additional background maps, also as screened reproductions on mylar, have been prepared including (1) the study area at 1:125,000 in two sheets, (2) the study area at 1:250,000 in one sheet and (3) the urban planning area in one sheet at 1:62,500.

Project Library

A project library was established to gather data pertinent to the study area and the particular subjects of interest to the problems of the study area. The project library lists over 700 acquisitions as of 1 September 1975, not including documents on loan from the Corps of Engineers.

The library task also included a canvas of most major libraries in the State of Washington to determine their resources with respect to the interests of this study.

Geology and Groundwater

A report on the geology and groundwater of the study area in general and of the urban planning area in detail was prepared for this study under subcontract with Shannon and Wilson, Inc., Geotechnical Consultants. This report covers the general geology and groundwater of the study area as a whole in overview terms and summarizes the results in two maps at 1:250,000 scale. The report on the urban planning area is in detail and covers, in addition to general geology and groundwater, a special study on the permeability of the surface and near surface soils. In addition to narrative descriptions, the results on the urban planning area are summarized on a series of maps at scale 1:24,000, one series each for geology, surface soils, near surface soils and groundwater. The geology and groundwater study is documented in Appendix B, Section 303.

Climate and Meteorology

Two approaches to climate and meteorologic data were taken. One was to accumulate a general understanding of the climate of the study area and the availability of data for normal engineering and planning use. The results of this study are documented in Appendix E, Section 304. The other was to accumulate the extremely detailed meteorological data necessary to implement the simulation model. For use in the simulation process refer to Section 11 herein and Appendix J, Section 606.1 and 606.4. The raw meteorological data acquired for the simulation are available in the project files on magnetic tapes.

Demographic and Economic Characteristics

A report on the present and forecast population and economic conditions of the study area as a whole was prepared under subcontract with consultant Andrew Trice, Ph.D., of Scotts Valley, California. The results of this study are documented in Appendix F, Sections 305 and 402. The control totals of forecast population in Section 402 are the basis for the detailed allocations of forecast population developed in Sections 402.1 and 403.

The allocation of forecast population in the urban planning area were made by computer using an update of the SMATS demographic model and forecast land use data. Mr. Raj Joshi of Human Resources Planning Institute, Seattle, provided consultation on this phase of the work. Results are detailed in Section 403.

Surface Water Characteristics

The characteristics of the surface waters are summarized in Appendix A, Section 308. Included are such characteristics as drainage area, river mile index, description of impoundments and hydroelectric installations as well as summary of hydrological data, maximum, minimum and mean stream flows. Also included are operations schedules of controlled releases, area-capacity relationships, bathymetric maps and brief descriptions of the principal natural lakes of the study area.

Detailed long-term hydrological data for statistical analysis is included in Section 410.1 along with the results of statistical analysis to determine the 100-year flood flow and 7-day 10-year low flow for the principal streams of the study area.

Land Use

Existing land use throughout the entire study area was mapped using a combination of City and County mapping and aerial photography. The results were plotted on the study area-wide backgrounds at scale 1:24,000 and for the urban planning area on the 1 inch equal 400 feet mapping. This existing mapping provided the basis for mapping of forecast use. The City and various County planning departments provided consultation and review of both the existing and forecast mapping phases. Forecast conditions are shown in Appendix F, Section 403 and referenced mapping.

Water Quality Data

A canvas of all available surface-water and ground-water quality sources and identified data gaps are reported in Appendix A, Section 307. Subsequently, specific but limited water sampling and analysis programs were undertaken as part of this study to fill identified data gaps and for the purpose of calibration of the simulation model. The surface water sampling and analysis programs are reported in Appendix J, Section 607.1 and 607.2. The ground-water sampling and analysis program is reported in Appendix B, Section 405. For the sampling and analysis programs, analytical services were provided under subcontract with the Environmental Engineering Laboratory of Washington State University. Special sampling and analysis in Long Lake were performed as a consulting service by Raymond Soltero, Ph.D., and associates of Eastern Washington State College.

The total water quality data, combining that previously available with that developed in this study, are summarized in Appendix A, Section 404, and Appendix B, Section 405, for surface-water and ground-water respectively.

Existing Wastewater Collection and Treatment Facilities

A canvas was made of the existing wastewater facilities of the study area, both municipal and industrial. The single most important "existing" facility is the committed upgrade and enlargement of the City STP. The design of this committed facility proceeded concurrent with this study. Early in this study reliance was placed upon the descriptions of the proposed facility in the predesign report of the consultant, Bovay Engineers. Subsequently, as design progressed, additional data became available. For this reason, minor inconsistencies may be noted between early and later study documentation. The survey of existing facilities included on-site inspections of all significant facilities except those of the two Kaiser industries. It was not possible to obtain permission from Kaiser to visit their facilities during the data gathering phase of the study. Reliance in their case is placed on their reports to DOE and letters updating these reports.

Existing wastewater facilities are summarized in Appendix D, Section 311.

Wastewater Sources

A canvas of existing point and non-point wastewater sources was made for the entire study area. Point sources of municipal and industrial wastewaters, their volumes and pollutant content are summarized in Appendix D, Section 312. Potential non-point sources are identified and evaluated in a series, Sections 312.5 through 312.8 covering solid waste disposal sites, soil erosion, urban runoff and agriculture.

Water Sources and Utilization

All categories of major water systems in the study area are identified, their water source or sources noted and use compiled. This includes municipal, industrial and agricultural categories. Estimates are made of agricultural water use in areas not served by irrigation districts where some form of record keeping is available. Water systems, sources and use are summarized in Appendix C, Section 313.

Environmental Conditions

An overview of the environment of the study area is provided in Appendix E, with emphasis on those aspects which might be expected to interact with wastewater management. Significant areas and types of vegetation are identified in Section 315.4. Fishery resources are identified and related to the present conditions of surface water in Section 315.51 which was prepared with consultation from Max Katz, Ph.D., of Seattle Marine Laboratories. Animal and bird resources of the study area are identified and located in Section 315.52. A brief survey of the air pollution situation in the urban area of Spokane is covered in Section 315.6.

Recreation

The availability of recreation opportunities and open space are factors frequently impacted by wastewater management alternatives. Existing recreation lands and facilities as well as open space and open space policy are summarized in Appendix E, Section 316. Projected recreation and open space needs are developed in Section 408. Both of these sections were prepared and reviewed with the assistance of local planning and recreation departments.

Water Quality Standards and Planning Requirements

A survey of Public Law 92-500 as it impacts this study together with information on applicable Washington State water quality and planning requirements is included in Appendix G, Section 317.

Cost Data

For the purpose of implementing cost-effective analysis of plan alternatives, it is necessary to develop cost data on a wide variety of treatment and conveyance facilities. For this purpose an extensive literature search was made to develop cost criteria. The results of this search are contained in a costing manual documented as Appendix G, Section 401.2.

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[1/] Section 306 and supporting plates not included in the report.

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[1/] Not referenced in Task Report but used in oral presentation by Dr. Todd.

APPENDIX III

ABBREVIATIONS

Ac	acres
Ac. ft.	acre feet
ADWF	average dry weather flow
BOD	biochemical oxygen demand
BPWTT	best practicable waste treatment technology
°C	Degrees Celsius
cap.	(per) capita
CEC	cation exchange capacity
cfs	cubic feet per second
chlor. A	chlorophyll A (indicator of algal concentration)
CITCOM	Citizens Committee for the Metropolitan Region Water Resources Study
conc.	concentration
co-op	inter-local cooperation contract
DO	dissolved oxygen
DOE	State of Washington, Department of Ecology
DSHS	State of Washington, Department of Social and Health Services
EDU	equivalent dwelling unit
ENR	Engineering News Record (cost index)
EPA	U.S. Environmental Protection Agency
°F	Degrees Fahrenheit
FCZD	Flood Control Zoning District
FIA	Flood Insurance Administration
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
HC	Hangman Creek
HSP	Hydrocomp Simulation Programming
ID	irrigation district
Kjel N	Kjeldahl nitrogen
LID	local improvement district
LSR	Little Spokane River
McAUTO	McDonnel Douglas Automation Company
Metro	metropolitan municipal corporation
mgd	millions of gallons per day
mg/l	milligrams per liter
ug/l	micrograms per liter
ml	milliliter
mm	millimeter
umhos	micromhos (conductivity)
NA	not applicable

APPENDIX III - Continued

NFIP	National Flood Insurance Program
No./100 ml	number of organisms per hundred milliliters
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	no-point-source
NS	North Spokane
OBERS	(Federal) Office of Economics and Business Research
O&M	operation and maintenance
ortho P	orthophosphate
pH	hydrogen ion concentration
PL	Public Law
pot P	potential phosphate
ppcd	pounds per capita per day
PWWF	peak wet weather flow
RCW	Revised Code of Washington
RM	river mile
SIP	Spokane Industrial Park
SMATS	Spokane Metropolitan Area Transportation Study
SPRIBCO	Spokane River Basin Coordinating Committee
SS	suspended solids
STP	sewage treatment plant
SV	Spokane Valley
TDS	total dissolved solids
ULID	utility local improvement district
URO	urban runoff
USGS	United States Geological Survey
USBR	United States Bureau of Reclamation
USPHS	United States Public Health Service
WAC	Washington (State) Administrative Code
WRIA	water resources inventory area
WWP	Washington Water Power Company
YR 2000	year 2000

APPENDIX IV

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